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ANDERSON'S GAS WASHER AND SCRUBBER.

THE main feature of the Anderson washer—or, as he terms it, a "combined washer and brush-scrubber"—is a brush-wheel revolving in water in the opposite direction to the gas-stream; and as there are several compartments of this kind, one above another (varying in size and number with the quantity of gas to be purified), this apparatus includes the best feature of the tower-scrubber—viz., the gas passes upward through purer water, or weaker liquor, till it reaches the uppermost compartment where the pure water enters.

The interior of each compartment is fitted with an axis from which projects a brush, made of whalebone or any suitable material. Mr. Anderson prefers to use the reedy material commonly employed in brooms for sweeping stables—having been led to adopt this material from noticing its good qualities when used by his gardener in the stableyard. There can hardly be a better, certainly not a cheaper material, inasmuch as, besides its suppleness and durability, each stem keeps its position well, and does not get into a mass—an important quality, since the perviousness of the brush is requisite for the efficient distribution, or application of the purifying action of the water. At each revolution, the brush dips into the water (which occupies the lower portion of the compartment) and comes out dripping; so that the gas is brought in contact, not only with the wet surface of the brush, but also with the drops of dripping water. The semicircular top of each compartment forms the bottom of the one above. The revolution of the brush-wheels is effected by a rod, worked by steam, carried down one end of the machine.

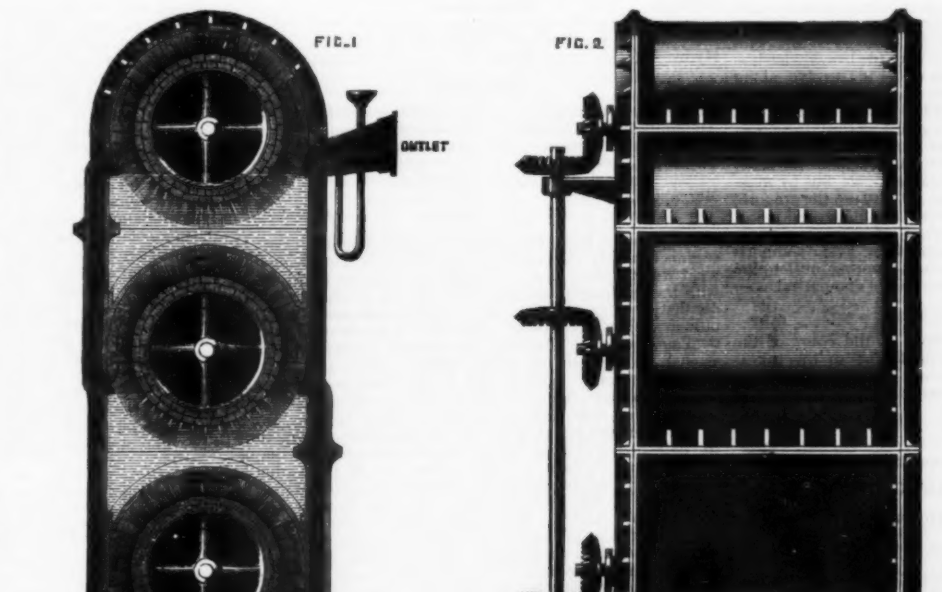
At the bottom of the apparatus, and before the gas ascends into those brush-wheel compartments, there is a simple washer, which is so placed and employed for the purpose of cleansing the gas from the finer tarry particles which usually escape from the condensers—whereby the brush-wheels are kept clean and unclogged. This washer at the bottom of the apparatus is one which Mr. Anderson devised many years ago, when he first began to give attention to the defects of the old kinds of washer, with the view of improving its structure, so as to bring the simple employment of water into use again in preference to the wet scrubber, which for so many years had been the favorite and also superior apparatus. It consists of a trough of water into which a series of serrated plates dip at intervals of about a foot; and if the gas really passed up and down (out of and into the water) between each of these serrated-edged plates, this kind of washer would be a remarkably good one. It is doubtful, however, if the gas will act so obligingly, it will probably take its course through the vessel on the principle of least resistance—the pressure of the gas "unsealing" a good many of the plates with a single rush. Nevertheless, this early-devised washer of Mr. Anderson's is found in practice to be tolerably efficient; and, placed as it is here, it is perfectly adequate for its purpose of condensing and washing out the finer particles of the tar, so as to keep the brush-wheels in the upper portion or main body of the apparatus unclogged. The pressure required for working this bottom part of the apparatus is decidedly a disadvantage; but it is not an essential part of the apparatus, and only the brush-wheels ought to be employed when the condensing apparatus is sufficient.

In his original draught of this apparatus, Mr. Anderson designed it horizontally—the flow of water continuously through all parts of it being effected by placing each compartment on a slightly higher level than the subsequent one. But the vertical arrangement of the compartments, adopted in his perfected invention, is manifestly much better—especially as saving space, which is so important a consideration in all urban gasworks. Moreover, any increase in the gas-make (and the gas-make is always increasing) can be readily and simply met by adding one or more compartments at the top of the apparatus. In fact, Anderson's washer offers perfect facilities for a great increase of size, and for every refinement of ammonia-purification that can be desirable in gasworks

On the very face of it, this new apparatus of Mr. Anderson's is a remarkably good one in every respect. In the first place, it has the merit of great simplicity; it can hardly get out of order, and is easily taken to pieces should the brushes need cleaning; while the apparatus itself is readily capable of extension in size, by the mere process of addition. Secondly, it brings the gas into contact with water far better than any of the old kinds of "washers," or even of the best kind of tower scrubbers—*i. e.*, the purifying action of the water is greater within the same space; and thirdly, as a consequence of this, the cost of the apparatus, relative to the amount of work done, is less than that of the tower-scrubber. Finally, as regards its power of extracting the last few grains of ammonia (which is absolutely impossible with any previous form of the washer), this new apparatus rivals the tower-scrubber in this, that the gas is passed through pure water last of all, in the uppermost compartment. The degree of purity of the water in the uppermost compartment, of course, will depend entirely upon the size of the apparatus and the quantity of gas passed through it. The tower-scrubber itself cannot contain pure water even at the top of it, when the quantity of gas passed through it is greater than the scrubber is capable of purifying from ammonia. The best apparatus in the world will not, of itself, insure a proper purification of the gas. What is indispensable is to manage the operations as Mr. Mann did with his tower scrubbers, namely: to adjust the quantity of the gas to the purifying capacity of the apparatus, so that the whole of the ammonia be extracted before the gas reaches the top part of each vessel, where the pure water enters.

The Anderson washer is suitable for gas works of every size, and not least so for the smaller class of works, owing to its perfect simplicity and also cheapness of construction. It is only in the London gasworks, and a few others of first-class magnitude, that it is necessary to thoroughly purify the gas from ammonia; and for these works this washer has been found to be very efficient. Where the gas must be purified even from the last grains of ammonia, the top compartment ought to be treated somewhat like a "reserve purifier;" that is to say, the gas should be passed through the apparatus only in such quantity as can usually be purified from the ammonia before entering the top compartment, in order that the water in this uppermost compartment may be so pure as to insure that no ammonia goes forward from the apparatus in the gas; for it must be borne in mind that ammonia is so volatile an impurity that if gas be washed with ammoniacal water (however weak the "liquor" may be), it is impossible to prevent some portion of the impurity from remaining in, or even being returned into, the gas. Were it desirable in any case (and such cases must be extremely few) to increase the delicacy of action of this washer without increasing its size, this might readily be done by substituting for the top compartment two compartments of half the height (each fitted with a brush-wheel of half the diameter of those employed in the other compartments), whereby the important point of bringing the gas into contact with pure water last of all, could be more readily insured.

One of the first places where this washer was erected was the St. Albans Gas Works; and in the published report, dated April 27, 1877, which the engineer of those works (Mr. A. F. Phillips) made on the new apparatus, and in which he speaks of it in the most favorable terms, the two points most worthy of notice are: (1) that "the brushes cause no appreciable increase of back-pressure;" and (2) that the apparatus "performs its work more efficiently than the lower-scrubber I have, while only about half the height, and not one-fourth its weight or capacity"—in other words, the ammonia purification was better done in about one-fourth of the space and size of apparatus.



ANDERSON'S GAS WASHER AND SCRUBBER.

The thorough efficiency of this new washer (or combined washer and scrubber) was demonstrated some eighteen months ago at the Vauxhall works of the Phœnix Company, where, thanks to the friendly courtesy of Mr. Woodall, I had an opportunity to see this new apparatus at work, and to ascertain what it actually does. The apparatus, as erected at Vauxhall, consists, besides the trough or tar-washer at the bottom, of five tiers of compartments, each containing a brush-wheel 4 ft. in diameter, and 10 ft. in length; so that the size is about 22 ft. in height, 4 ft. in depth, and 10 ft. in breadth. The quantity of gas passed through it was about 35,000 ft. per hour, and the quantity of water was 18 gallons per ton of coal. The purifying power of the vessel may be shown, in the first place, by the state of the water

or liquor in the several compartments. The following is a statement of the ammoniacal strength of the liquor in those compartments which were really at work—"10 ounce" liquor being liquor which requires 10 ounces of sulphuric acid to neutralize the ammonia contained in a gallon of it:

Bottom trough, or tar-washer	10-oz. liquor.
First brush wheel compartment ..	8 "
Second ditto.....................	3 "
Third ditto......................	only a trace of ammonia.
Fourth ditto.....................	Clean water.
Fifth ditto	"

Manifestly the apparatus was underworked, so that a larger quantity of gas might have been passed through it.

One of the testings made at Waterford appears to show the full power of the apparatus, and is, therefore, worth giving. The following table shows the strength of the liquor in each compartment, the quantity of water passed through the washer being 11 gallons per ton of coal carbonized:

	Strength of liquor.
Bottom trough........................	16 oz.
First brush-wheel compartment.........	14
Second ditto..........................	5·4
Third ditto...........................	2·2
Fourth ditto	0·4
Fifth ditto	pure water.

It is almost needless to add that 15 oz. or 16 oz. of liquor is more than enough, when mixed with the weak liquor from the condensers, to make the whole ammoniacal liquor produced on the works up to 10 oz. strength, which is the highest strength desirable.

We may add that Mr. Anderson, in some cases, makes a slight alteration in the mode of working his brush-wheels—namely, by making the top brush-wheel to revolve along with the course of the gas, instead of contrary to it, as is the case in the lower compartments. The object of this modification of the apparatus is to guard against the pressure of the gas forcing some of the water into the outlet pipe for the gas, which is about 2 in. higher than the inlet pipe on the opposite side of the compartment; but by making the brush revolve along with the gas stream, the pressure of the gas on the water can be reduced to the desired point. A similar gas-pressure upon the water, of course, exists in all of the compartments; but in each of the lower compartments any water thus forced into the ascending outlet pipe for the gas simply falls back again into the compartment.—*Engineering.*

ONE of the best tests of autographs is the color of the ink. In genuine ancient writings the fading of the ink is irregular; in forged documents the ink has the same color throughout, and the most ingenious of forgers have been unable to overcome this difficulty.

[Continued from SUPPLEMENT No. 188.]

GAS AND GAS MAKING.—II.

By L. P. GRATACAP, Ph.B.

THE PROCESS.

THE manufacture of gas involves two steps—first, the generation of the gas, and, second, its purification. And whereas the first depends largely upon the raw material worked, viz., the coal, both as to the properties and volume of gas obtained, the second is under the manufacturer's control—is, indeed, the direct application of methods and apparatus to accomplish a known result, which is more or less perfect according to the adequacy of the means employed. Heat is the means employed to form and expel gas from coals, and cannel and caking bituminous coals form the material usually expected to yield it. These minerals yield, upon the application of heat, a large volume of gas, tar, and ammoniacal liquors, which, separately collected, form three commercial products, variously related in quantity and quality, according to the conditions of heat under which they are made.

The familiar experiment of luting a perforated lid upon a small porcelain crucible, in which is placed a fragment of these coals, exposing the vessel to a naked flame, and lighting the current of volatile bodies which issues from the aperture, and becomes visible as a wisp of flame, exactly illustrates the process in use upon a practical scale in our gas houses. The small crucible is replaced by banks of clay and iron retorts, so built over and around a central fire as to receive its heat most advantageously; the fragment of coal, by charges of 200 lb. of coal; the aperture, by ascensional pipes, which conduct the gases from the mouths of the retorts up to one general receptacle, where the mixed products from the entire bank commingle; the lid, by an iron mouthpiece, screwed tightly on by a threaded handle; and luted by lead films or a cement of mortar and fire clay; the naked flame, by a grate fire plied constantly with coke, and kept in such a vigorous combustion as to raise the heat of the retort up to 2,200° F. These retorts, almost universally made of clay, are ⌂ shaped, are some seven feet long, and are arranged in tiers through the length of the retort house, inclosed in a wall of brick, and surmounted by a line of pipes, which connect with them and collect their individual yields of tar, gas, and ammonia water into the hydraulic main, the common reservoir into which all these conduits dip. Each set of five or seven retorts are heated by a single fire of coke, except where the Siemens regenerating furnace is used, whereby one center of consumption may heat 128 retorts, provided its heat is distributed by means of regenerative chambers beneath each bench of eight retorts. As their contents become exhausted they are charged by the workmen with additional coal, by means of long, trough-shaped scoops of iron, which are filled with coal, and thrust into them with remarkable dexterity and precision, then overturned and withdrawn, and the covers sealed on before the volumes of gas which burst out from the hissing piles are lost, either by escape or ignition. The discussion of the load of coal sealed up within this narrow chamber and dissolved by the power of heat into such various elements is of the greatest interest, and to the engineer in its practical, and to the chemist in its theoretical, bearings, offers equal and paramount attractions.

We may reasonably expect to find in the gases evolved those very gases occluded in the coal as it lies in coal seams, which have been produced by a process of slow combustion or distillation, and which have been expelled from natural coals at a temperature of 100° C., by Mr. J. W. Thomas, upon their exhaustion *in vacuo*, viz., carbonic oxide, carbonic acid, marsh gas, ethane, quartane, oxygen, and nitrogen. And, in reality, these are all present in the crude gas, except that the paraffine gases, ethane and quartane, are largely replaced by olefiant gas and olefines, upon whose illuminating power the gas-maker relies for the efficiency of his light, and which may be formed *de novo* in the process of distillation, or reformed by the decomposition of those higher, more complex hydrocarbons. Besides these, there are, in fact, a number of other luminants of a high gravity formed in the distillation, diluents or non-luminous gases, and, as every element is set free, and in its escape forms those unions which its affinities prompt, a great number of impurities. In short, the original coal is broken up by the disassociating power of a high heat, which, besides effecting the mechanical liberation of its component atoms and molecular groups, imparts to these nascent bodies a chemical activity and sympathy which converts the retort into a laboratory, where an elaborate series of syntheses and reductions are taking place, with an intensity, rapidity, and complexity of which only the extraordinary lists of products obtained in the gas, ammonia water, and tar can suggest an adequate conception. Thus the constituents of the gas alone, and its impurities, as given by Dr. Chandler, make a formidable array:

Luminants.

Paraffines,	Acetylene,	Diphenyl,
Propyl,	Valylene(?)	Anthracene,
Alcohol radicals,	Benzole,	Pyrene,
Olefiant gas,	Toluol vapors,	Chrysene,
Propene,	Phenylene,	Phenol.
Butene,	Cinnamene,	
Olefines,	Naphthalene,	

Diluents.

Hydrogen,	Marsh gas,	Carbonic oxide.

Impurities.

Sulphureted hydrogen,	Ammonium sulphocyanide,
Ammonium sulphydrate,	Ammonium cyanide,
Bisulphide of carbon,	Ammonium mono-carbonate,
Oxysulphide of carbon,	Carbonic acid,
Sulphurous acid,	Nitrogen,
Mercaptan,	Oxygen,
Sulphur bases,	Water.

The question instantly occurs, To what extent can the gas engineer modify the results obtained in the retort, and in what way? There can, of course, be no direct interference with the inevitable assortment of bodies produced by the distillation of coal; but that assortment can be quantitatively influenced by the engineer's control over the heat, the analytical agency which dissipates the atomic household known as coal, and permits the erratic affinities of its parts an undisturbed action. With a high heat he can produce more gas of a thinner character, and less illuminating power, but composed of more inflammable and higher heating gases, as hydrogen and marsh gas. The hydrocarbons which form the light-giving element of the gas are destroyed by simplification, *i. e.*, division, or their carbon lost by deposition in the form of graphite upon the sides of the retort or in the interstices of the residual coke. For the heavier bodies which would condense after sublimation are unable to withstand the molecular agitation produced by the high heats, and fall apart into simpler and gaseous forms, and thus the gas volume is increased by a redistillation of these tarry bodies, otherwise lost in the hydraulic main. With a low heat the oils increase and the gas diminishes, but this gas is of a high illuminating power, and heavy, the amount of heat requisite to convert the solid hydrocarbons into gas, or to break up into simpler bodies the rich and luminiferous gases and vapors, not being supplied. The contrasted effects of high and low heats are shown to an extreme degree in this table:

2,240 lb. of Newcastle coal yielded:

1. When distilled for gas at a high temperature.		2. When distilled for oil at a low temperature.	
Gas	7,450 cu. ft.	Gas	1,400 cu. ft.
Coal tar..........	18½ gals.	Crude oil...	68 gals.
Coke............	1,200 lb.	Coke.......	1,280 lb.

It is evident, then, that a gas engineer must avoid, if he wishes to make a gas commercially attractive, high heats, whereby the illuminating power of his flame is diminished, and its heat uselessly and uncomfortably increased; and equally shun low heats, whereby he generates a gas of a brilliant quality, but industrially expensive from the small volumes obtained. There are other considerations which render this latter working objectionable, as condensation, smoky flames, etc., to be mentioned hereafter. The engineer is naturally desirous of seeing a good showing on his station meters, and recommending the management of his works by a large yield, and a promised proportionate increase of revenues to the company; but he must bear in mind the necessities of the consumers, and conciliate their tastes and wishes by a flame of beauty and brilliancy. It is sometimes difficult to neutralize these opposite tendencies by any satisfactory compromise. But he is assisted here by a proper use of his power to regulate the phases of distillation in the retort, in a second way, *i. e.*, lengthening or shortening the duration of the charge before the retort is emptied or refilled. A moment's view of the sequence of events in the retort will explain the relative importance and meaning of these two methods. The charge of coal after inclosure in the retort becomes at first heated to the point of distillation only on its superficies, and heavy carbonaceous vapors pass upward against the heated arch of the retort, where they absorb the heat necessary to change them into permanent gases, and these primary gases formed from the richest distillate are of a high illuminating power, olefines, acetylenes, etc. As the upper coals become exhausted of their gaseous bodies, the surface becomes a red hot mass of coke, through which the vapors, oils, and gases from the interior must now pass, and in their transit become fixed. The tendency of this action is plain enough. The final products becoming exposed to greater heats, as well as more extended surfaces already heated, are progressively decomposed from the heart of the charge outward, until reduced to thin heating gases, of little or no photogenic capacity, and there are produced, a short time after the charge is thoroughly heated somewhat beyond the temperature of distillation, poorer and poorer gases. In other words, a long time charge yields quantity rather than quality of gas, and, on the contrary, short time charges afford a better quality of gas with reduced production.

Dr. McAdam, of Edinburgh, has compiled the following table from his own experiments in this matter, wherein the first line opposite each coal represents the results of a long time charge, 4 hours, and the second line those of a short time charge, 3 hours, affording a very clear proof of the deterioration of the illuminating properties of the gas simultaneously with an increase of volume:

	Yield of gas from one ton of coal. Cubic feet.	Illuminating power of 5 cu. ft. of gas in standard candles.
Heywood cannel....	11,153	30·97
	9,333	34·87
	1,820	3·90
Bank gas coal, upper seam............	10,080	27·67
	8,516	31·45
	1,564	3·78
Bank gas coal, upper and lower seam...	10,126	27·07
	8,468	31·28
	1,658	4·21
Lochgelly parrot coal	10,040	26·24
	8,460	29·82
	1,580	3·58
Raith parrot coal...	9,630	25·61
	8,180	29·26
	1,450	3·65
Average............	10,205	27·51
	8,591	31·33
	1,614	3·82

From this Dr. McAdam concludes that the legitimate purposes of gas manufacture are best subserved by the short time charges applied to cheap coals, that the gases lost are valueless, and that the increased photogenic power and the pecuniary gains made by using cheaper coals more than compensate for the loss of gas in the long time charges. In fact, if the gas is not to be enriched by further additions of luminiferous oils, the practice best calculated to secure satisfactory results to both consumer and manufacturer is 3½ hour charges of 200 lb., at a temperature of 2,200° F., or a heat approaching orange whiteness, using mixed caking coals and low cannels.

In still another way the engineer is permitted to influence the composition and character of his gas. By the use of mixed coals in the charges he can successfully correct the peculiarities of the separate products of one or other coals, assist their desirable, and regulate their objectionable features. Generally speaking, an inferior and superior coal are to be used together, the light giving properties of the richest gas being diluted and mechanically held in suspension in the thinner and poorer product, while the latter's more combustible gases provide the amount of heat needed to raise the hydrocarbon particles to incandescence in the flame. Dr. McAdam has subjected this hypothesis to practical demonstration, and established by his results the favorable and important changes secured:

Cannels.		Yield in cu. ft.	Candle power in standard candles.
Separately distilled.	1	9,768	27·07
	2	11,153	30·97
Distilled together.	1 and 2,	10,714	32·27
Separately distilled.	1	9,434	26·81
	2	11,452	29·39
	3	10,552	37·16
Distilled together.	1, 2, and 3,	10,677	32·96
Separately distilled.	1	11,789	30·60
	2	11,153	30·97
	3	9,434	26·81
	4	11,525	30·26
Distilled together.	1, 2, 3, and 4,	10,752	32·48

Thus, through the adroit commixture of his coals, having previously determined the assemblage and proportions of gases obtained by their separate distillation, and the character of their individual flames, the engineer prescribes with more or less certainty the style of gas he wishes to produce, and may even delicately vary its less obvious features, exercising a tolerably efficient control over the reactions within the retort itself.

It is impossible perhaps to overestimate the desirability of his understanding the constitution of the gases made from his different coals, nor too strongly to emphasize the necessity of his own patient study of the results. The chemical reactions of gases in a nascent state, the precise effect of different treatment as regards heat, pressure, etc., is an obscurely defined subject, and invites earnest and original investigation.

The gas and other products, as they pass away from the retorts, rise up in the ascension pipes and down the dip pipes, and bubble through the seal of tar and water already collected in the long iron tube called the hydraulic main. From this point forward cooling ensues, accompanied by condensation of vapors, steam, etc., and the agglomeration and falling of the tar particles mechanically conveyed along in the hot rush of the gas from the retorts. The gas, loaded with impurities, diluted by vapors, steam, volatile salts, etc., is in no commercial state, and before it is salable must undergo the process of purification. Condensation is the first step in purification, naturally, may be said to be physical, and involves certain explicit and recognized laws, which practically are often ignored, and perhaps more frequently never known. Briefly stated, the facts observed by physicists concerning the condensation and deposition of gases and vapors are these: "In a mixture of several vapors derived from substances having no solvent action on each other, the vapors act towards each other as permanent gases. When the temperature of the mixed vapors is reduced, the vapor having the lowest tension is precipitated from the other as from a permanent gas; a portion of the vapor having the lowest tension being held in diffusion by the vapors having the highest tension, till it reaches the point of condensation, when the whole is condensed together. 2. In a mixture of several vapors derived from substances which dissolve each other in all proportions, when the temperature is reduced, a portion of the whole of the vapors is simultaneously condensed, the quantity of each being dependent on the difference in tension between the vapors and the relative proportions in which they are present. 3. A mixture of several vapors derived from substances which only partially dissolve each other, on being reduced in temperature, follows in part the laws previously given, dependent on the proportion of each vapor present." (Letter of William Young to London *Gaslight Journal.*)

The application of these laws is obvious. In the mixture of crude vapors, gases, and steam to be condensed, the bodies

which it is desirable to separate are solvents, in smaller or greater proportions—especially the heavier hydrocarbons—for those bodies which it is desirable to retain, and consequently should the volume of mixed products be suddenly cooled to a point below the point of tension of its most condensable elements, the precipitation of these latter would involve that of the lighter, more permanent, and useful compounds which were dissolved in them.

These are removed, since by the effect of solution their freedom is impaired and their vapor tension lowered. Slow cooling, on the other hand, permits the disengagement of the lighter gases from the embrace of their heavier companions, whose solvent action is reduced thereby, allowing the volatile bodies to escape more readily and more completely. Literally this implies fractional condensation, the purport of which in the more advanced methods of condensation is the use of heat, actually to maintain the gas at successively lower degrees of temperature, until the heavier bodies drop out, and the light gases become materially freed from their chemical and mechanical bondage amongst the former.

Condensers are iron pipes, upright or horizontal, small or large, cooled by water or air, arranged in compartments offering some 100 feet of surface to every 1,000 cubic feet of gas cooled per hour, and in communication with vaults or wells where the ammonia water and tar are collected. In the application of the principle elucidated above, a secondary and valuable result is secured, that of retaining hydrocarbons in the gas, which dissolve a body called naphthaline, which frequently solidifies out of the gas and clogs mains and service pipes, but which disappears in the presence of an excess of these hydrocarbons. Another fact in this connection is that it includes the rubbing out of the gas the mechanically suspended particles of tar. These are hurried along in the current, and settle only at those points where a momentary resistance from pressure on a new surface, change of direction of flow, or retention before narrow apertures allow them to separate, from the slackened force of the gaseous tide which carries them on. MM. Pelouze and Andouin have utilized this action in the construction of an apparatus which effects partial purification by the emission of the gas through narrow orifices, in jets which impinge upon metallic plates, where they deposit their tarry particles. The gas, now in a great measure freed from the tar, oils, etc., which were mingled with it, and cooled down to a temperature of 70° or 80° F., begins to assume a more usual appearance, and is in a condition to be chemically treated, which its original thickened and turbid condition forbade.

Three impurities yet remain in it which the subsequent steps of purification are calculated to remove. These are carbonic acid, ammonia, and sulphureted hydrogen, of which for the present it may be said that the two last are objectionable on sanitary grounds, and the former for its deleterious influence on the flame.

The ammonia exists in the gas in the form of a sulphide, a carbonate, a sulphohydrate, a cyanide, a sulphocyanide, and free or caustic ammonia, and their elimination depends upon the solubility of these bodies in water, the ammonia itself being soluble to the extent of 770 parts in 1 part of water. But we might infer from the presence of the carbonic acid, which actually exceeds the quantity of ammonia in the gas by almost four per cent., that from its chemical antagonism it would neutralize the alkali and remove it from the gas as an acid or neutral carbonate. Though in this sense the gas, so far as ammonia is concerned, appears to possess within itself the power of self-purification, it cannot under the given conditions be completely realized.

Carbonic acid, water, and ammonia will not unite below 136·4° F., or 58° C., and hence we find in the water from the condensers free ammonia, taken out of an atmosphere which is charged with four times the amount of carbonic acid requisite to form an acid salt, and eight times the amount needed for a neutral salt. As the gas cools, these salts are formed, with a preponderance of the neutral carbonate, for, as Berthelot has observed, the acid salt proves unstable, at the lowest temperature displaying a tendency to decompose. Similarly the ammonia and sulphureted hydrogen refuse to combine at temperatures above 134·6° F., or 57° C., and unions between them undergo partial or entire disassociation at high heats.

Therefore the gas next undergoes washing or scrubbers, virtually identical operations, the theory of which is that the gas in a finely divided state should pass in an opposite direction to a shower of minute particles of water, and in this way, interpenetrated by the spray of the latter, surrender its ammonia. The process of washing or scrubbing is practically more than this: it corrects the inefficient working of the condenser, cools the gas still more, and decreases carbonic acid and sulphureted hydrogen. It is impossible to overestimate the necessity of breaking up the water and gas in as perfect a way as possible if this washing is to be final, and every device has apparently been exhausted to effect this multiplication of the points of contact between the gas and the water. The disposition usually adopted is to make the gas rise up through a pile of coke, rubble, brush, lattice work, and other mechanical devices for splitting, and, as it were, pulverizing the gas, through which from above a shower of water is constantly passing, seizing wherever exposed to mutual contact the minute atoms of all soluble impurities.

Another consideration which renders this division imperative is the fact that its thoroughness enables an engineer to use less water and to diminish the time or space—the same thing—through which the gas is exposed to washing, and thus conserve in the gas those illuminants which water will inevitably filch from it, if too abundantly provided with good opportunities to commit the theft.

The best effects, especially as relates to the carbonic acid, are gained by cooling the gas sufficiently before its entrance to this water bath, and in summer, owing to the difficulty of effecting this thoroughly, carbonic acid passes through the scrubber but slightly diminished in volume. The ammoniacal water once used can be pumped over again with excellent results, as a sort of agglutinative affinity is set up between the ammonia atoms, and the caustic ammonia attacks and removes sulphureted hydrogen.

In the perfect theory of gas making the prolongation of the action of condensation beyond the condensers should be made as unimportant as possible, as the water acts with more certainty, effectiveness, and economy in removing the ammonia the cleaner and lighter the gas is.

The movement forward of the gas through the condensers and scrubbers demands an increasing pressure, and the gas would be retarded altogether, partially, or these alternately, unless helped through by the engineer, who practically removes this pressure by sucking the gas out from the scrubbers by means of the exhauster, machinery which pumps literally the gas from the scrubbers and condensers, enabling it to pass instantaneously upon its formation from the retorts. Thus the gas is secured as it is made, and removed from the heat of the retort, which would simplify its composition by breaking up the luminiferous hydrocarbons, whose rejected carbon would deposit on the sides of the retort, rendering it less pervious to heat, less capacious, and impoverishing the gas in the same proportion as well.

From the exhaust the gas meets the purifiers, and the engineer encounters the varied and difficult problem of removing the sulphur and carbonic acid.

THE LIGHT AND ENERGY OF ELECTRICITY AND GAS.

By J. T. SPRAGUE.

SOME very remarkable statements were made before the Committee of Parliament on Lighting by Electricity. These statements are embodied in the report, and having gone the rounds of the press without examination or comment, they will, no doubt, be adopted as settled facts. It is, therefore, very desirable that they should be examined, and that an understanding should be arrived at as to how far they are reliable, and in what sense they are true. We will, therefore, commence with the remarks of Sir William Thomson.

1,746. We are anxious to obtain your opinion upon various points connected with electric lighting; perhaps you will let me go to the root of the matter, and ask you to tell us the energy which is used and exhibited as light in the production of the electric arc?—The energy which is actually used in the electric arc is about 1 horse power per 2,400 candle power, or even more than 2,400 candle power, according to the dimensions and other circumstances of the electric arc.

1,747. That is to say, 1 horse power, if fully employed, produces 2,400 candles or more?—Yes, 1 horse power actually in the electric arc; 1 horse power spent in stirring the luminiferous ether between the carbon points and on the surfaces of the carbon.

1,748. Have you at all calculated the energy appearing as light in the case of the combustion of gas?—1 horse power of energy in the combustion of gas produces about 12 candle power.

1,749. And 1 horse power converted into electric light produces 2,400 candles?—Yes.

1,750. As these are rather startling figures, perhaps you will explain to the committee how you arrive at such results?—Sir William's reply is too lengthy for full quotation, as the greater part of it is unimportant; he concludes, by saying: "The upshot of all is that, allowing the practical estimate of 1 horse power actually spent in driving the engine to produce 1,200 candles, which has been realized, I estimate that one half of that power goes to the electric arc, and one-half is lost in heating different parts of the machine. *This then gives 2,400 candles for 1 horse power*, which is the figure of my answer. In respect to gas I have taken 4 candles per cubic foot of gas per hour. I have taken the heating power of gas at 12,000 centigrade units per gramme; I have taken the specific gravity of the gas as half that of air, and calculated accordingly. I have thus calculated the *whole heat of the combustion of gas*, from the amount of that per second of time, and reduced it to horse power. Thus I arrive at the figure which I gave in my answer, *i.e.*, 1 horse power actually spent in warming the air and stirring the luminiferous ether in a gas flame of 12 candle power.

The committee in their report remark that there is some difference of opinion between the scientific and practical witnesses, and it is not to be wondered at if the foregoing is to be taken as a type of scientific evidence. In fact, the statements are all true, but they are so arranged as to constitute a complete chain of special pleading, and to convey an absolutely false impression of what the facts themselves really mean. The statements are *true as to the energy actually in the lights*. The impression they produce *is false as to the energy necessary to produce the lights*.

There are two ways of considering energy, as with most other things. There is the *potential* or theoretical energy of a combustible; that is to say, the total heat capable of being produced by its union with oxygen. This potential energy of coal, for instance, is about 13,000 centigrade heat units per lb. In commercial language, we may call this the *gross* energy of the coal. There is, again, the *practical* energy of the combustible, a function of the boilers and engines. For instance, average steam engines give a horse power for 7 lb. of coal per hour; this, in commercial language, may be called the net energy of the coal.

Now, what Sir William Thomson has done is just this: he has charged the gas light with the gross energy, and the electric light with the net energy, as indicated by the italics in his evidence, and people who do not understand this, like the writers in the daily press, of course imagine that these figures so seriously stated are really true.

Now let us see what would come of an equitable comparison, using as far as possible Sir W. Thomson's own figures. 1 horse power is 33,000 ft.-lb. per minute, or 1,980,000 per hour. Expressed in heat units of 1 lb. water 1° Cent., which equals 1,390 ft.-lb., 1 horse power per hour equals 1,424·5. This, then, is the potential energy of the 4 cubic feet of gas, giving 12 candles light.

To put the 1 horse power of energy into the electric arc another 1 horse power is of necessity expended in the circuit and must be charged, because the gas compared with it is the whole amount necessary. But to produce 1 horse power in a steam engine involves a consumption of coal varying from 2·5 lb., in the most perfect and expensive engines known, to 8 and even 10 lb. in common engines; let us take 4 lb. as a very fair engine's work, and we have 8 lb. coal expended in generating the 2,400 candles mentioned. Now, the potential energy of 1 lb. of average coal is 13,000 heat units, or, in 8 lb., 104,000.

Instead of having the energy per candle:

Gas	1,424·5	÷ 12	=	118·7
Electricity	1,424·5	÷ 2,400	=	0·597

This being what Sir W. Thomson makes it appear to be, we have, by equitable comparison:

Gas............... ..	1,424·5	÷ 12	=	118·7
Electricity...........	104,000	÷ 2,400	=	43·3.

Even then we have omitted a very important element of consideration: the gaslight needs no machinery, no capital outlay, no skilled attendance; the electric light wants all these, and if they do not form an element of the scientific calculation as to potential energy involved in the two cases, they enter very largely as factors in the practical calculation as to the potential cost. Hence the difference in the practical and so-called scientific opinions noted in the committee's report.

The comparisons made are, however, intrinsically erroneous, because made between electricity in its best conditions on the large scale, and gas in its worst, on the small scale, and it is well known that in all things the small scale is most costly, whether we consider the expenditure of money or of energy. But, in addition to this general principle the comparison is not really made with an electric arc having 1 horse power of energy expended in it. The estimate is made from a light having 3 or 4 horse power in it; in this way the value is arrived at "of 1 horse power actually employed in driving the engine to produce 1,200 candles," and as only half this energy is in the arc, the light equal to 1 horse power is taken as 2,400; but it is well known that to produce a light of 1,200 candles in a single arc requires 2 horse power of engine, and in those conditions the 1 horse power energy would be actually in the arc, and the efficiency would be:

Electricity .... 104,000 ÷ 1,200 = 86·6

as against gas 118 7 per candle, and this when setting the production of a 12-candle light against one of 1,200.

It may be well to explain why the actual energy expended in the luminous area is so much smaller with electricity than with any combustible such as gas. In the case of combustion the energy has to be employed in heating the products of the combustion, steam and carbonic acid and a large bulk of neutral nitrogen from the air; these all flow rapidly away and carry off the heat. The very same loss has to be met in the electricity when derived from combustion, but the loss occurs, not in the light, but in the furnace and in the wires; here pure energy is collected and transmitted to the arc, where it makes its appearance as light unencumbered by the products of the processes of the transformation of latent energy into light and heat. Still, as the loss has to be incurred in both cases, both the lights when compared must have the total energy needed for their development taken into account.

The same witness expressed opinions as to the transmission of power from central engines to different parts of towns by means of electricity, but as Mr. Siemens gave the figures upon which these opinions are founded, we may now pass on to examine these. Mr. Siemens, comparing the cost of gas and electricity, says: (136.) "Making the unit of comparison 1,000 standard candles per hour, the results are striking. An Argand burner produced 1,000 standard candles of light per hour, with a consumption of 312·5 cubic feet of gas; and to make this, 56 lb. of coal would have to be used in the retorts." (139.) "In the case of a medium dynamo-machine driven by a gas engine, 19·5 cubic feet of gas produce 1,000 standard candles during one hour; and the consumption of coal necessary to produce this gas is 3·26 lb." (141.) "And in the case of the naked light the consumption of coal is very nearly the same?—It is very nearly the same; it is 13·3 lb. in the gas engine, and 12 lb. in the steam engine, showing that the gas engine is really a very economical engine, and has moreover the advantage over the steam engine, that no boiler is employed, and that the consumption of gas commences and ceases the moment the motion of the engine commences and ceases."

It will be seen presently that this advantage of the gas engine is very much understated, because the coal corresponding to the gas is largely overestimated.

The comparison between the relative weights of coal consumed is really of little importance, because the real thing to be considered is the relative costs. The cost of gas is, of course, greater than that of the mere coal it represents, because its price includes labor, capital, and distribution; on the other hand, the coal consumed in the other case must be charged with wages, etc., necessary for its consumption to place it on the same footing as the gas with which it is compared. But when any comparison is made or any line of argument adopted it ought to be correctly worked out.

Now, instead of an Argand burner giving the light of 1,000 candles on a consumption of 312·5 ft. of gas per hour, this value is calculated from the work of 62 Argand burners, each consuming only 5 ft. per hour of 16-candle gas. No burner of 1,000 candle power has been made. But burners giving 250 candles on a consumption of 60 ft. are made, so that we know that 1,000 candles can be obtained from 240 ft. instead of 312·5. But Mr. Siemens commits a more serious injustice when he charges against the gas the whole of the coal put into the retort, allowing nothing for the coke and tar, which form part of the actual coal with which he is comparing the gas. In this way he obtains a consumption of 15 lb. of coal per hour with gas as against 8 lb. consumed in a steam engine to develop the 2 horse power necessary to develop 1,000 candles in one electric arc.

A ton of average coal gives 9,600 ft. of gas of 0·450 sp. gr., which equals 331 lb. of purified gas per ton; about 1,300 lb. of coke are produced, and if we reckon the excessive consumption of one-third of this in the furnaces and charge the whole of this against the gas produced, we shall find that we get about 12 ft. of gas for each pound of coal which has disappeared—that is to say, 100 cubic feet of gas represent at most 8 lb. of coals. This reduces Mr. Siemens' 56 lb. per 1,000 candles to 25 lb. on the consumption of 5 ft. Argands, and to 19 lb. on the actual consumption in 4 of the 250 candle burners.

This shows the great economy of the gas engine as compared with the steam engine. Gas engines are already in use which develop 1 horse power per 21 ft. of gas, which represents at most 1·6 lb. of coal, and this efficiency is realized in small engines. But the very best steam engines of large dimensions have never realized more than 1 horse power for 2·5 lb. of coal, and this only with great attention. Ordinary engines consume 8 and 10 lb. per hour per horse power, and a consumption of 4 lb. would be very good work for any engine employed under general conditions analogous to those for which gas engines would be used. The reason of this economy is that the potential energy of the fuel is converted directly into mechanical energy in the cylinder by the act of combustion; only so much is necessarily carried off as goes with the heated products containing only the small quantity of vapor due to the hydrogen in the gas. With steam all this loss occurs in the furnace of the boiler, and in addition there is the immense quantity carried off in the escaping uncondensed steam.

We now come naturally to the question of transmitting power. Mr. Siemens says: (200.) "I believe it would be the cheapest mode of transmitting power to a considerable distance. The experiments which we have made give a result of a loss of 50 per cent., that is to say, 5 horse power applied to a dynamo-machine produces, roughly speaking, 2½ horse power at a distant point; it would follow that, say, 100 horse power engine at a central station, which could be worked with a consumption of 2·5 lb. per horse power, would produce at a number of points, power at the rate of 5 lb. per horse power."

Mr Siemens thinks more favorable results may be hoped for than 50 per cent. return; but it is a pretty general law in

electricity that the resistances must be equal in generator and utilizer, and there are reasons for this, which the resistance expresses, though it is itself an agent and not the cause; hence 50 per cent. is the full theoretical efficiency, allowing nothing for loss in the conductor and by leakage; in actual working the total efficiency would be more likely 30 to 40 per cent.

But giving electricity its utmost claim, and the use of the best engines known, we have a consumption of coal of 5 lb. per horse power delivered, as against 1·6 lb. per horse power delivered by gas. But we have to consider something besides the theoretical consumption of coal. The 21 ft. of gas at 4s. per 1,000, costs 1d., while 1d. would buy 9·3 lb. of coal at 20s. per ton. But the 1d. in the case of gas covers the whole cost of the delivery of the energy of the coal to the machine which uses it. In the case of coal it represents, on the other hand, energy which has to be delivered; to place the electric energy of that coal on a par with the gas we have to provide and pay for:

1. The capital outlay, wear and tear of the steam engine, and its attendance.
2. The dynamo machine which generates the electric current, and all its subsidiary expenses.
3. A conducting system, the conditions and difficulties of which are as yet absolutely untested.
4. The general expenses of management and the profits of the undertaking.

These simply represent the gasworks and mains, and the expenses and profits of the gas company, all of which are included in the penny charged for the horse power of gas. The consumer would have in either case to provide a gas-engine or dynamo-electric apparatus, the costs of which would be about the same.

It is quite certain that the expenses of all this would raise the cost of the 5 lb. of coal consumed at the central station to considerably more than the penny; in fact, they would be so great that it is not surprising that no one has yet ventured to dispute the remarks made some time ago on Mr. Siemens' proposal to transmit the energy of waterfalls 30 miles distant, or of the coal at the pit's mouth. The power costing nothing at the 30 miles distance, it would be better economy to allow to run to waste, its delivery would cost more than the expenses of carriage of coal, which has to be paid for, and its conversion into gas in the different towns as required.

As the writer himself is working at the problem of electric lighting, and is the patentee of machines which will be brought into operation in a little while, it will be understood that there can be no intention to depreciate the importance of these applications of electricity. But the statements examined will no doubt be utilized ere long by the various prospectus writers, who are waiting their opportunity; and it is of great importance that their actual meaning should be understood and the real truth be presented to the public understanding.—*English Mechanic.*

THE GREAT SUSPENSION BRIDGE BETWEEN NEW YORK AND BROOKLYN.—PAY OF OFFICERS, ENGINEERS, AND WORKMEN.

The East River Bridge has afforded employment to many thousands of workmen since its construction was begun on the day following New Year's in 1870, but of the great number who have come to and gone from the work, four only remain who began to work on the first day. The number of men on the bridge work has varied from 10 to about 900. Recently there were 797 men at work on the bridge, irrespective of the officers of the Board and the engineer corps. The laborers all work by the hour, and their wages are paid at the end of every two weeks. The whole amount thus far expended for labor on the bridge is $1,538,162.53. The amount of the pay roll per week at present is $8,325, but a year ago it was about $1,000 more. This does not include the pay roll of the engineers, which is $3,169.17 a month, or that of the officers of the Board, which amounts to $1,231.65 a month. The list of engineers and their pay per month is as follows: Col. W. A. Roebling, chief engineer, $833.33; C. C. Martin, assistant engineer, $500; W. H. Paine, $333.33; Francis Collingwood, $300; George W. McNulty, $208.34; S. R. Probasco, $250; W. Hildebrand, draughtsman, $220.84; W. Vanderbosch, inspector of stone, $190; E. F. Farrington, master mechanic, $333.33. Total, $3,169.17.

The pay of the officers of the company, by the month, is as follows: Henry C. Murphy, president, $416.66; John H. Prentice, treasurer, $333.33; O. P. Quintard, secretary, $333.33; John Garvey, clerk, $83.33; A. L. Curtis, clerk, $65. Total, $1,231.65.

The pay of the different laborers by the hour is as follows: Ship carpenters, 30 cents; painters, 22½ cents; riggers, 15 cents; day laborers, 12½ cents; stone masons, 30 cents; helpers, 10 cents; machinists, 25 cents; day watchmen, 12½ cents; night watchmen, 15 cents; blacksmiths, 30 cents and 25 cents; blacksmiths' helpers, 17½ cents and 15 cents; inspector, 35 cents; assistant to inspector, 25 cents; master machinist, 40 cents; steam engineers, 20 to 35 cents; foremen, 25 cents to 40 cents; assistant engineers, 17½ to 20 cents; hod carriers, 17½ cents; carpenters, first class, 25 cents; carpenters, second class, 20 cents; carpenters' helpers, 15 cents to 17½ cents; draughtsmen, 30 to 40 cents; tool dressers, 25 cents; stone cutters, 25 cents; brick masons, 30 cents; stone masons' helpers, 15 to 17½ cents; brick masons' helpers, 15 cents; drivers, 15 cents; general foremen, 40 cents; assistant foremen, from 25 to 35 cents; laborers, 10 to 12½ cents; messengers, 20 cents.

The pay of the bricklayers was recently increased to thirty cents an hour. The pay of the carpenters varies according to their skill, there being now thirty-three employed at thirty cents, thirty-six at twenty-five cents, and ten at twenty cents an hour. The men are employed by the engineers, and there are no recommendations needed beyond skill and physical ability. There is no number of hours fixed for the men, but their work has usually been confined to ten hours a day, although when there is any special feature of the work which is being pushed, the men work twelve hours a day.

There is an *esprit de corps* about the employés of the bridge which the engineers say they have never seen exhibited on any other great work. This was particularly the fact when the cables were being made. The different gangs of men worked with energy and zeal in their different branches, and that difficult part of the work was completed in a much shorter time than was anticipated. There is not needed a harsh word at any time to keep the work moving. Every man understands his duty, is prompt and willing, and the best of feeling has existed all the time between the men and the engineers. In a short time a larger force of men is to be put on the work to tear down the buildings in the track of the approach in this city, and to make excavations for the masonry. Probably nearly 1,000 men will be engaged in the work in a few weeks.

In Brooklyn there are now employed: 2 draughtsmen, 1 assistant to the civil engineers, 1 assistant to the inspector, 1 time keeper, 1 receiving clerk, 1 messenger, 5 day watchmen, 3 night watchmen, 1 blacksmith, 1 tool dresser, 2 helpers, 10 engineers, 2 assistants, 2 engineers, 2 firemen, 2 foremen of riggers, 78 riggers, 4 foremen of laborers, 109 laborers, 1 foreman of carpenters, 9 ship carpenters, 11 carpenters, 6 second class carpenters, 2 carpenters' helpers, 1 foreman of stone cutters, 14 stone cutters, 1 foreman of stone masons, 16 stonemasons, 3 foremen of brick masons, 38 brick masons, 24 stone masons' helpers, 37 brick masons' helpers, 1 foreman of drivers, 1 stable man, 9 drivers, 10 horses and carts, 1 general foreman, 2 drivers, 1 stone breaker, 6 skilled laborers, 2 boys. Total, 419.

In New York there are employed: 4 ship carpenters, 2 foremen, 1 painter, 17 riggers, 6 laborers, 1 helper, 2 stone masons, 1 rigger, 1 foreman of blacksmiths, 1 blacksmith, 4 blacksmiths' helpers, 3 machinists, 1 machinist's helper, 4 day watchmen, 4 night watchmen, 3 blacksmiths, 3 blacksmiths' helpers, 1 inspector, 1 assistant to inspector, 10 ship carpenters, 1 master machinist, 10 engineers, 3 assistant engineers, 2 helpers, 2 boys, 5 foremen, 52 riggers, 26 carpenters, 4 second class carpenters, 2 carpenters' helpers, 3 draughtsmen, 1 receiving clerk, 1 messenger, 1 tool dresser, 6 stone masons, 17 stone cutters, 42 brick masons, 45 hod carriers, 10 stone masons' helpers, 22 brick masons' helpers, 9 drivers, 1 general foreman, 5 assistant foremen, 20 laborers. Total, 368.

In the stone yard at the foot of Dikeman street, Brooklyn, there are employed: 1 foreman, 1 day watchman, 1 night watchman, 1 engineer, and 6 riggers. Total, 10.

In answer to the many inquiries reaching the bridge office, a card has been printed containing the following facts about the structure;

Construction commenced Jan. 2, 1870; size of New York caisson, 172x102 feet; size of Brooklyn caisson, 168x102 feet; timber and iron in caisson, 5,253 cubic yards; concrete in well holes, chambers, etc., 5,669 cubic feet; weight of New York caisson, about 7,000 tons; weight of concrete filling, about 8,000 tons; New York tower contains 46,945 cubic yards masonry; Brooklyn tower contains 38,214 cubic yards masonry; length of river span, 1,595 feet 6 inches; length of each land span, 930 feet—1,860 feet; length of Brooklyn approach, 971 feet; length of New York approach, 1,562 feet 6 inches; total length of bridge, 5,989 feet; width of bridge, 85 feet; number of cables, 4; diameter of each cable, 15¾ inches; first wire was run out May 29, 1877; cable making really commenced June 11th, 1877; length of each single wire in cables, 3,578 feet 6 inches; ultimate strength of each cable, 12,200 tons; weight of wire, 12 feet per pound; each cable contains 5,296 parallel (not twisted) galvanized steel oil coated wires, closely wrapped to a solid cylinder 15¾ inches in diameter; depth of tower foundation below high water, Brooklyn, 45 feet; depth of tower foundation below high water, New York, 78 feet; size of towers at high water line, 140x59 feet; size of towers at roof course, 136x53 feet; total height of towers above high water, 278 feet; clear height of bridge in center of river span above high water, at 90° F., 135 feet; height of floor at towers above high water, 119 feet 3 inches; grade of roadway, 3¼ feet in 100 feet; height of towers above roadway, 159 feet; size of anchorages at base, 129x119 feet; size of anchorages at top, 117x104 feet; height of anchorages, 89 feet front, 85 feet rear; weight of each anchor plate, 23 tons; total cost of bridge, exclusive of land, $9,000,000. Bridge will probably be completed in 1880. Engineer, Col. W. A. Roebling.—*N. Y. Sun.*

ON THE REQUISITE THICKNESS OF CAST-IRON WATER PIPE UNDER HEAVY PRESSURE.

By C. H. M. Blake, C.E.

Having lately had occasion to draw up specifications for water pipe, where the pressure to be provided for is somewhat excessive, my attention was called to the radical difference in the results obtained by the working formulæ generally used in American practice, in comparison with English and French authorities, the former results being much in excess of the latter. This is the more surprising when we consider that our iron is much superior in tensile strength to the foreign brands. Valuable information of the comparative strength of American and English cast iron can be found in "Ordnance and Armor," by Holley, 1865, pages 309–10. I quote: "An American cast iron, having a tensile strength of 49,496 lb. per sq. in., has been quite recently applied to cannon founding. But cast iron does not average 50,000 nor even 40,000 lb. tensile strength. The average of five samples of the highest quality, mentioned by Capt. Rodman, in "Experiments on Metals for Cannon," 1861, is 31,000 lb. Mr. Longridge gives the strength of *English* gun-iron at less than 20,000 lb. ("Construction of Artillery," Inst. Civil Engineers, 1860), and states that in the Blue Book of 1858, containing the Woolwich experiments: "The maximum strength of cast iron there tried was 33,600 lb., the minimum 10,080 lb., and the average strength 22,400 lb. These experiments were made upon iron prepared and sent especially by the makers, and doubtless considered by them as the best for the purpose. The result of Mr. Hodgkinson's experiments, recorded in his edition of Tredgold, showed an average tensile strength of 15,680 to 16,800 lb. per sq. in.; Lowmoor iron being 14,560 lb. and Carron iron 14,560 to 15,680 lb. From the Report of the Commissioners on the Use of Iron in Railway Structures (1849), it appeared that the tensile strength of Bowling iron was 13,440 to 15,120 lb., and that of Lowmoor, 15,680 lb. per sq. in. The average of the Nova Scotia iron, specimens of which have recently been tested, gave only 15,287 lb., and some of the Scotch pig iron, selected at random, only gave 12,912 lb." From the foregoing tests it would appear that English iron should not be assumed of greater tensile strength than 15,000 lb. per sq. in., and, even then, should be cast under careful supervision, while the American iron could safely be relied upon for considerably greater cohesion. I find the best English formulæ assume a tensile strength of 15,000 lb. per sq. in. (Baldwin Latham, "Sanitary Engineering," p. 80; Humber's "Water Supply," p. 154), and yet adopt much lighter weights for heavy pressures than are derived by calculation from our formulæ. Mr. Shedd tested some 300 samples of iron used in the Providence water pipe, and found the ordinary strength to be from 18,000 to 28,000 lb. per sq. in.

The late Mr. Kirkwood, Engineer of the Brooklyn Water Works, gives the strength of iron used for pipe there at from 20,000 to 22,133 lb. per sq. in. From the above results, if the pipes are properly inspected in casting, it is safe to assume American iron as possessing a tensile strength of 18,000 lb. per sq. in. Let us assume a pressure of 110 lb. to the sq. in. to be provided for in a 12 in. pipe. The *theoretical* formula for thickness is $t = \frac{p\,r}{s}$, in which p = pressure in lb. per sq. in., r = radius in inches, and s = tensile strength of iron per sq. in. Substituting values, the above equation becomes $t = \frac{110 \times 6}{18,000} = 0{\cdot}0366$ in. But, in practice, a pipe must have the following characteristics:

1. It must be of sufficient strength to be handled with safety.
2. It must be strong enough to bear the water ram, in addition to the normal pressure.
3. It must have an additional strength for life of pipe and imperfection in casting.
4. It must contain metal enough to fulfill the foregoing requirements, without subjecting the casting to its full capacity of strength, or, in other words, a factor of safety must be used.

Let us assume a factor of safety of *three*, or subject the metal in no case to a greater strain than 6,000 lb. per sq. inch, and tabulate the various factors required to build up the thickness of the pipe under discussion. We will first consider what thickness a 12-inch pipe must possess to be transported and laid with safety. Fortunately, we can ascertain this factor from the experience in handling gas pipe, which must, of course, be of the requisite strength. I find it to be $\frac{53}{100}$ of an inch. It is evident, therefore, that a 12-in. pipe must be, *at least, half an inch thick*, without regard to the pressure it is to be subjected to; but when it requires this or a greater thickness for its proper duty, *no further allowance should be made for safety in handling;* but the majority of the formulæ in use fail to eliminate this factor, and the result is, a useless ring of metal is used.

The *water ram* must be provided for. Fanning, in his treatise on "Water Supply Engineering," says (page 450): "With proper stop and hydrant valves, it is not probable that the momentum strain will exceed that due to a steady static head of 200 or 225 ft." As the water ram is *independent of the normal pressure*, depending on the velocity of flow and the rapidity with which the flow is checked, the allowance for ram should be uniform for different pressures, while many formulæ have a factor *proportionate to the pressure*, which evidently must make either too small an allowance with light heads or too large with heavy pressures. The allowance for a 12-in. pipe will be, in thickness of casting, taking the ram equal to a pressure of 100 lb. per sq. in.:

$$t = \frac{100 \times 6}{6,000} = 0{\cdot}1 \text{ in.}$$

Tabulating the various factors required, we have:

Theoretical thickness	0·0366 in.
Allow for factor of safety	0·0732 "
" water ram	0·1000 "
" life of pipe and imperfections	0·2000 "
Total thickness	0·4098 in.

But we have seen that a 12-in. pipe should be 0·53 in. thick to be transported safely, and must, therefore, add 0·12 of an inch for safety in handling, which gives us the required thickness of 0·53 in., or, say $\frac{17}{32}$ of an inch, weighing 69 lb. to the lineal foot. Applying formulæ in common use in the United States, I find the thickness under the same pressure would be in one case 1 in., weighing 138 lb. to the foot, and in another case 0·8 in., weighing 102 lb., showing an excess of 69 lb., and 33 lb. per foot, respectively. Taking iron pipe at $26 per gross ton, this would entail an increase in cost, in the first case, of 80 cents per foot, and in the second of 38¼ cents per foot.

Neville's (English) formula would give a thickness of 0·67 in.; M. Dupin's (French), 0·63 in.; Barlow (English), 0·43 in.; and Baldwin Latham considers a 12-in. pipe, 0·5 in. thick, capable of standing with safety a pressure due to a head 228 feet (125 lb. to the sq. in.), assuming strength of iron at 15,000 per sq. in. only. If the same reasoning be applied to other sizes of pipe, it will be found that where the pressure to be provided for is at all unusual, the formulæ in general use will give excessive weights, much heavier than sanctioned by the best English or French authorities. In the present depressed condition of business, which has caused the suspension of so many needed public improvements, it would seem to be the duty of engineers to prosecute work intrusted to them with the strictest economy in details, without allowing any element of weakness to enter into their plans.—*Engineering News.*

AUTOMATIC FEED WATER APPARATUS.

This apparatus is the invention of Mr. S. G. Cohnfeld.

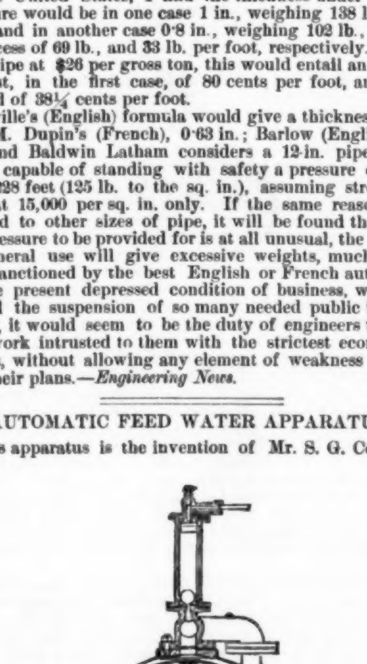


Fig. 1.

and is constructed at his works in Zankeroda, in Saxony. It consists of an upright iron cylinder, divided into two

compartments, A and B, by a horizontal wooden block. The two compartments are in communication by means of two U-shaped pipes, the size and arrangement of which are clearly shown in the drawings. The suction pipe, C, enters the upper compartment, B, and the steam-pipe, *e*, containing the acceleration column, R, enters the lower compartment, A. The other end of the steam enters the upright tube, *p*, which is provided with a Black's feed water alarm, and reaches down to the normal water line. The lower compartment is connected with the feed part of the boiler by the pipe, *d*. The suction pipe, *c*, and the pipe, *d*, are provided with valves which close automatically under an overpressure of steam or water.

As long as the apparatus is not in operation, and as long as the level of the water closes the lower end of the pipe, *p*, it is entirely filled with water. If the level sinks, steam will enter *p*, and pass into A through the pipe, *e*. On account of this equalization of the pressure in the boiler and apparatus, the valve will open itself, and the water will pass from A into the boiler. During this operation the bronze rod, *i*, in the accelerating apparatus, is in its lowest position, and gives a free passage to the steam. As soon as the level of the water in A sinks as low as the elbow in the U-shaped pipe, *b*, the steam will pass up into B, and force the water contained therein into A, condenses there, and thus causes the valve, *m*, to close, and the flow of water from A to the boiler ceases. The difference of the pressure forces the tube, *i*, into its highest position, and closes the steam off from A. The steam in B will now also condense, and the vacuum thus produced opens the valve, *n*, draws water from the tank, I, and fills the entire apparatus. The air escapes through the valve, *l*, consisting of a rubber ball. The apparatus remains inactive as long as the water closes the lower end of *p*, but as soon as the water falls sufficiently to expose this end, the operation just described will repeat itself. It acts entirely automatically, with clear and distinct pulsations. A steam whistle will blow in case there is no water in the reservoir, I.—*From the Chemiker Zeitung.*

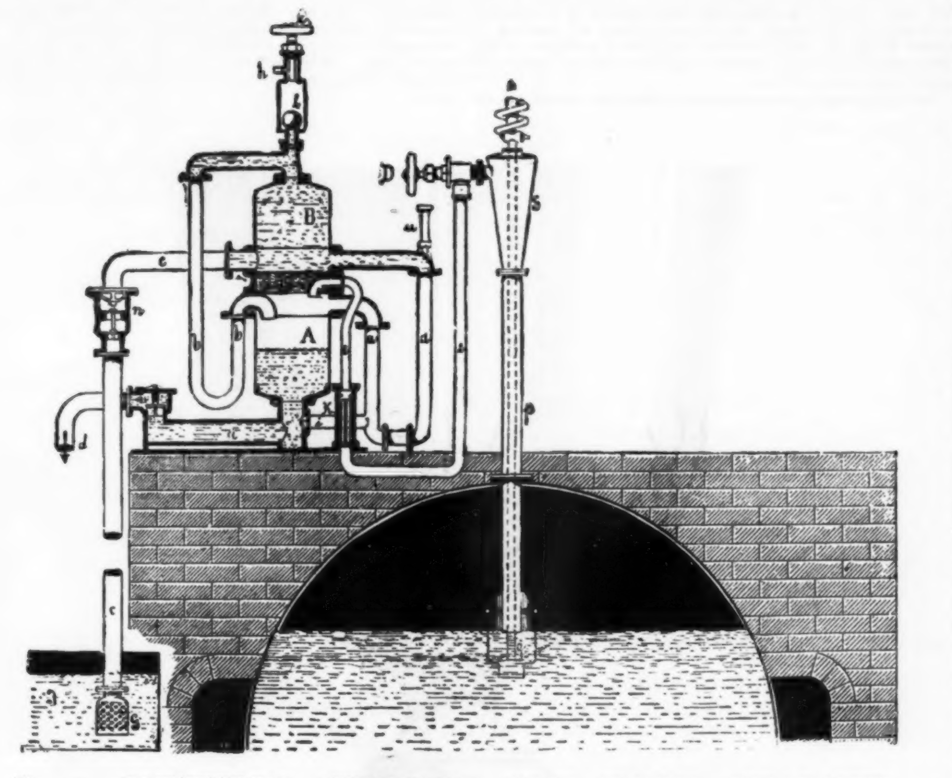


FIG. 2.—COHNFELD'S AUTOMATIC FEED WATER APPARATUS.

THE POLYPHEMUS.

THE torpedo ram, Polyphemus, now being constructed in Chatham Dockyard, appears likely to be the most extraordinary ship that has yet been built. She is novel and peculiar alike in form, structure, fittings, and arrangement of armor protection; while her weapons of attack are such as will necessitate her being fought differently from any other war ship. Her design was described by the late Mr. Ward Hunt in the House of Commons on the 12th of March, 1877, as being "of a kind as yet unknown in any part of the world, but which has been much talked about, and has been at last forced upon me by that gallant officer who stands at the head of the veteran list of the navy, viz., Sir George Sartorius, who has shown that although his age is great, his mind is still youthful, and that he is willing to receive new ideas and able to inculcate them."

The leading features of the Polyphemus are a strong ram bow, a powerful torpedo battery, great speed and handiness, moderate size, and a small extent of surface above water exposed to the enemy's fire, such portion of the vessel as is above the water line being convex in form, so as to deflect any projectile that may strike it. The appearance she will present when at sea will be that of a cylinder, floating on its side and deeply immersed, which is tapered at the ends to form a bow and stern. The top of the cylinder will be 4 ft. 6 in. above the water line, and will be flattened over a large portion of its area to form a deck. The whole of this flattened cylindrical surface will be plated over with steel armor, and will cover in and protect the ship and all her machinery and fighting appliances. The ship proper as she will thus appear will be surmounted by a light structure carrying a hurricane deck of about two-thirds her length, and upon this deck will be seen a signal mast, funnel, pilot tower, boats, and other fittings.

Under water the form of the Polyphemus is as strange as it will thus appear above. The cylindrical curvature of the sides is carried down several feet below the water line, and armor-plated to that depth. Below this point the section assumes a V form, and ends in a sharp angle at the keel. It will therefore be seen that a complete cross-section of the vessel is very similar to that of a peg-top. The flattened convex curvature of the upper part of the peg-top would represent the part of the Polyphemus that is above water, and the lower portion, which ends in a point, would also represent the part of the ship that is below water. If the peg-top be imagined to float in water at a depth below where its breadth is greatest and where the section thus begins to curve towards the central line, a rough idea may be obtained both of the form and proportions of the above and under water parts of the Polyphemus.

The Polyphemus is 240 ft. long between perpendiculars, 40 ft. in extreme breadth, and will have a load draught of 20 ft. Her displacement will be 2,640 tons. The convex armored deck will be 4 ft. 6 in. above the water line, and will be completely plated over with steel armor 3 in. thick. This armor will be carried to a depth of 6 ft. to 7 ft. below the water line. The Polyphemus will not be fitted with masts or sails, but will carry a pole for signaling purposes and for making observations from. She will be propelled by twin screws, and will have two pairs of high-pressure compound horizontal engines, which are being constructed by Messrs. Humphreys & Tennant, of Deptford. Each high-pressure cylinder will be 38 in. in diameter and the low pressure 64 in. The stroke will be 45 in. The boilers will be of the locomotive type, twelve in number, and will be made of steel. They will work up to a pressure of 110 lb. per square inch. It is estimated that the engines will indicate a collective power of 5,500 horses, and that the speed of the ship will be 17 knots.

The only offensive weapons the Polyphemus will possess are a powerful ram bow and Whitehead torpedoes. She will have no guns at all, except a few light shell guns and Gatlings on the hurricane deck for the purpose of repelling boat or torpedo attack. The ram will consist of a very strong spur, which will project 12 ft. in advance of the stem of the ship, and is so placed that it will strike several feet below an enemy's armor. It will be connected to the stem and bow by deep web plates and angles on each side; the former being a continuation of the 3 in. deck armor, which is curved downwards at the bow and carried under water till it reaches the level of the spur. The spur is being fitted so that it may be unshipped and taken off the stem when not required for active use. Under the ram is a torpedo port, which will enable Whitehead torpedoes to be ejected right ahead of the ship. There are also two torpedo ports on each side amidships, from which they will be ejected on the broadsides. The ports and apparatus for working the torpedoes will be upon the system fitted in the Vesuvius and Glatton. All the torpedo ports are below water, but it is understood that this under-water attack will be supplemented by torpedo firing above water from the armored deck upon the system adopted in ordinary torpedo launches.

Above the armor-plated portion of the hull a hurricane deck is fitted for about two-thirds of its length. This deck is about one-half the extreme breadth of the ship. Communication is made between the hurricane deck and the interior of the ship by openings cut through the armored deck. The openings thus cut are protected by glacis plates and armor, and by casings, which are carried up to the hurricane deck. The boats are carried upon the hurricane deck, and the ship is steered and worked from it. An armored pilot tower, with protected means of access to the lower part of the ship, is placed at the fore end of the hurricane deck, and fitted with steering wheel, telegraphs, voice pipes, apparatus for firing off the torpedoes, and all other appliances for conning and working the ship. A few light shell or Gatling guns will also be carried on the hurricane deck, as we have stated, for repelling boarders or torpedo boats.

The Polyphemus is built throughout of steel. The frames are of Bessemer, and the bottom plating of Landore-Siemens steel. She is constructed upon the usual system of transverse bracket frames and continuous longitudinals, and has a double bottom the whole length of the ship right up to the upper deck.

The subdivision of the lower part of the ship into small watertight compartments has been carried as far as appears possible. The double bottom is split up into a large number of cellular spaces, and the hold is divided by a longitudinal middle line bulkhead, and numerous transverse bulkheads. The boilers are contained in four separate watertight compartments of the hold, three being placed in each; and each pair of engines is also contained in a separate watertight compartment. The advantage of such an arrangement is sufficiently obvious in view of the possibility of one of the boilers or engine-rooms being bilged by a blow from a ram or torpedo. The double bottom is arranged so as to include the coal bunkers, as in the Devastation and Inflexible. By these means buoyancy is gained if one of the compartments is opened up to the sea, as the water can only find its way among the interstices of the coal, and a large quantity is thus kept out of the ship.

The cabins and accommodation for the crew will all be below the armored deck, and will be ventilated artificially, as in the ironclad monitors. They will be lighted throughout by the electric light, which is already being fitted in several ironclads, and is likely to become extensively used for this purpose. An electric light will also be fixed in the look-out on the polemast, for reconnoitering and signaling purposes.

The most remarkable and novel feature in the ship yet remains to be described. The bottom plating on each side, instead of ending in a keel, or flat keel plate, at the middle line, is formed into a recess; so that in place of a keel there is a rectangular groove, 1 ft. 8 in. wide and 3 ft. deep, taken out of the bottom of the ship. This groove or recess is intended to be filled with cast iron ballast up to a weight of 300 tons. The ballast will be cast in several lengths, and will be so attached to the ship that, in the event of a compartment becoming bilged, and its being desirable to lighten the ship, the ballast can be let go and dropped from any part, as may be required. The draught and trim may thus be regulated to a certain limited extent should the vessel be damaged in action. This is a point that will probably be discussed among the engineers. The object of carrying the ballast seems to be to keep the ship down in the water, and prevent the deck from becoming too much exposed when the ship is uninjured; but should she become still further immersed from any cause, the dropping of the ballast will somewhat relieve and lighten her. The utmost effect of the ballast will be to enable the vessel to float 12 in. to 14 in. lighter when it is dropped than she would do before. In other words, although her armored deck is only 4 ft. 6 in. above the water, and this height only is exposed to the enemy's fire, the surplus buoyancy, on account of the ballast, will be the same as though the armored deck stood 5 ft. 6 in. or 5 ft. 8 in. above the water line.

It will be obvious that this quantity of ballast, amounting to about one-ninth of the whole weight of the ship, cannot be carried about for nothing. It adds to the work the engines have to do, and a greater expenditure of engine power for a given speed will be required to enable the ship to drag the ballast about with her. The additional engine power that will be required to drive the Polyphemus at full speed, after adding the ballast, will necessitate an increased coal consumption of 9 to 10 per cent., and a corresponding reduction in coal endurance. It will hardly be considered necessary to carry about all this dead weight in time of peace; and it will be a question for practical consideration whether the carrying of it about in time of war at a cost of reduction in speed, or in coal endurance—and this in a ship whose coal supply is very small for her power—will be compensated for by the armored deck being 4 ft. 6 in. out of water, instead of 5 ft. 6 in.

The Polyphemus is more or less of an experimental character, and the building of future ships possessing some or all of her characteristics will depend upon the results of her trials. She is not likely to create a great revolution in war shipbuilding, or to show that guns are unnecessary in a fleet. Indeed, it must be evident that there are many operations—such as the bombardment of fortifications, which could only be carried out by ships armed with guns.

The question respecting the Polyphemus is not whether such vessels as she are to supersede gun vessels, but whether she may not serve the more humble, though very useful, purpose of starting a type of war ships that will be valuable auxiliaries in action. Mr. Ward Hunt, on the occasion before referred to, spoke of her as follows:

"This vessel must, of course, to a certain extent, be regarded as an experiment, and, even supposing it to be a success, I could not propose it to the House as being likely to supersede all other kinds of fighting ships, but only as a useful adjunct to a fleet in case of war. Probably it would not be desirable that she should be kept at sea for a long period at a time, but I venture to think she will prove a very formidable weapon, and, if she should be a success, she may perhaps be regarded as a sort of rival to those monster ships with tremendous armor that we hear spoken of as likely to be built in some foreign ports."

The Polyphemus was commenced in September, 1878, and is already far advanced, being entirely framed and plated, except at the extreme ends. Great progress is being made with her, and she could be got ready for launching in a very few months.—*London Times.*

THE AUSTRALIAN BREAKWATER.

THE plans of the South Australian breakwater were designed by Mr. Hickson, the Colonial Government engineer for harbors and jetties. Mr. J. Robb has contracted to carry out the works for £107,456. About 500,000 tons of granite are to be used in the breakwater, but the bulk of this vast mass will not be above water even at low tide. The breakwater is to be 1,000 feet long, and it is to run out from the northeast corner of Granite Island in the direction of the obelisk at Port Elliott. At the sea end the water is 30 feet deep. The breakwater will only be 30 feet wide at the top, and even at low water mark the width will only be 75 feet; while at the bottom of the sea the breadth of the solid mass of granite will be no less than 245 feet, or over 80 yards. The side which faces the sea will be a gradual slope—1 in 4½—and will extend 165 feet out from the top of the breakwater. The inner slope will be 1 in 1, and it will only be 50 feet in extent. Each of the outer stones above low water is to be not less than 20 tons in weight, and the whole of the sea face of the breakwater is to consist of these enormous blocks right down to the bottom of the sea. The "hearting" will be made up with blocks ranging from one to ten tons (in different sections), the larger blocks being of course used furthest from land. Nearer the shore the sides of the breakwater will be properly squared, but dry, one ton blocks being here used. The huge 20 ton blocks will be simply let down by a crane into as nearly a correct position as possible. When a sloping wall of these blocks 165 feet in extent has once been formed, it is not regarded as likely that even the heaviest swell which comes from the Southern Pacific Ocean to Victor Harbor will be able to move them much. Although the breakwater now being erected will only be 1,000 feet long, plans have been prepared for 2,000

feet more to be added if deemed advisable hereafter. The jetty and causeway are great works in their way, but not to be compared in magnitude to the breakwater. Mr. Robb's contract price for the former is £11,271, and for the latter £96,185. The whole of the works are to be completed by the summer of 1881.

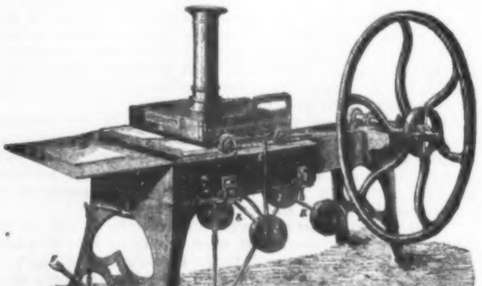
THE WEAR OF STEEL RAILS.

MR. A. M. WELLINGTON, under the direction of Mr. C. Latimer, chief engineer, has made an investigation into the comparative wear of the various brands of steel rails laid on the Atlantic and Great Western Railroad. The object in view was to determine the following points as accurately as circumstances would permit: The comparative wear of rails of various makes, the probable average life of steel rails, the increase of wear due to grades and curvature, and finally, the increase of wear due to speed, irregularities of surface, etc. Sections were carefully taken with the aid of a simple apparatus specially adapted for the purpose, and all rails tested were taken out of the track and weighed. Two rails opposite to each other were taken out as a rule, both on curves and on tangents, and in some cases four or more. The number of rails tested on curves was 75, on tangents 57, and at points of reversed curvature 8, or 140 in all. Unfortunately the original weights per yard could not be exactly ascertained. Other circumstances, the varying conditions of speed, ballast, use of brakes, and of sand, which cannot be exactly recorded, prevented full precision in the results, which are of value, however, as close approximations. The average wear of all steel rails taken up on tangents was 0·92 lb. per yard per 10,000,000 tons duty. Some of the most reliable tests made, however, as for example those for which the original weight was exactly known, showed somewhat above 1 lb. per yard per 10,000,000 tons, which is therefore assumed to be the most correct average for all rails (equivalent to 14,000,000 tons for $\frac{1}{16}$ in. wear). Under favorable circumstances, or with lots of extra good quality, the wear appeared to be but little more than half this. Judging by the views and opinions of several of the roadmasters of the road, the safe limit of wear for ordinary steel rails appears to be about $\frac{5}{8}$ in. in height, or 14·1 lb. of weight per yard. A committee of the American Society of Civil Engineers estimates the safe wear at only $\frac{1}{4}$ in. in height, while an official French publication places the allowable wear at a still less limit, or only 0·4 in. for a 60 lb. rail. All these estimates, however, appear to be based upon rails which were not worn out, but which approached more or less closely to the assumed limit of wear, and the estimates all appear to be too small. It is safe to assume the ultimate life of ordinary steel on a tangent at 140,000,000 tons, running up to at least 200,000,000 tons for extra qualities.

NEW IRONING MACHINE.

MECHANICAL SAD IRON.

THIS machine was exhibited by Ruhemann & Jacobi, at the Berlin Industrial Exhibition of 1879. It mangles and irons the material at the same time, and thus saves considerable labor. It consists of a hollow iron slab, A, provided with small wheels which run upon the tracks, B B, and has a reciprocating motion imparted to it by the crank, D, and adjustable connecting rod, C. The slab is heated



MECHANICAL SAD IRON.

either by gas, admitted into the same through the tubes, E E, or by means of hot blocks of metal, which are placed into it. The table, H, is lowered by depressing the treadle, G, whereby sufficient space to introduce and arrange the material is obtained. The weights, J J, adjustable on the rods, K, produce the desired pressure. The material can be ironed smooth or with ruffles, as may be desired.—*Illustrirte Gewerbe Zeitung.*

A NEW DEVELOPER FOR DRY PLATES.*

THE matter I have to bring before you this evening concerns developers and restrainers, more particularly for gelatine plates. When I use the term "restrainer," I wish you to understand that there are at least two kinds of restrainers—one that retards the development by allowing the reduction to take place slowly without requiring any increase of the exposure, and the other where an increased exposure is necessary. It would appear that this latter restrainer will undo partially or wholly the effect produced by the light when acting on the sensitive plate.

Now we all know that a collodion film that has been acted on by light can be re-sensitized by subjecting the film to a wash of a solution of iodide of potassium and redipping in the silver bath. I think the bromide salts act in a similar way, and consequently these salts are valuable when a picture is overexposed or the light has got to the plate.

In developing gelatine plates, it struck me that if a mixture of pyro and ammonia possessing keeping qualities could be prepared, it would greatly simplify matters. I will not here state the many substances I have tried, but inform you that one of the best and most rapid developers I have tried is composed as follows: To ten ounces of a nearly saturated solution of ferrocyanide of potassium, I add ten drops of strong liquor ammonia and fifteen grains of pyrogallic acid. If this be kept from the light and air it will darken in color very slowly, and will retain its energy for a very long time. I have to-day tried some made about five weeks ago. At first it would not develop, but the addition of a few drops of ammonia set up the action at once. I now know which way its energy fails by the following tests: If free ammonia be present and development does not take place, then pyro is wanted; on the contrary, if pyro be present and no development take place, ammonia is required. I see no reason why the solution should not be used over again, merely adding pyro and ammonia, and of course filtering the solution before the fresh addition.

I have not found the dark color of the solution detrimental in the least. I fancy it is rather advantageous if the color be dark before use, for there is then less chance of staining the film, as the stain has already taken place in the solution. I have the opinion of several gelatine workers that the developer is more rapid than the ordinary alkaline pyro. I reckon it to be about a third quicker. I mean that you can expose your plate a third less. The color of the image is a brownish yellow, and unlike the alkaline pyro.

Having so far conquered the difficulty of keeping the developer ready for use, I will now speak of intensification, *i.e.*, where it may be necessary. I have tried some dozens of formulæ, and I regret to say all have failed more or less in giving a clean picture. The formula given by Swan—*i.e.*, double iodide of mercury and potassium—is about the best, but there is the risk of spoiling the negative by the gradual darkening of the image when many prints are wanted. I rather think we shall have to look for a solution of this difficulty to a toning method—say the old and much despised hypo and gold bath.

Referring again to development, I find that when all the detail is visible in the shadows, the addition of a few drops of a saturated solution of boracic acid stops the development, but allows intensification to go on. I need scarcely say that the price of boracic acid will compare favorably with bromide, the former being a few pence per pound.

The last matter I have to mention, is my method of reducing excessive density, or clearing off red fog without there being any danger of alteration going on in printing. We should know that perchloride of iron or hydrochloric acid will only convert the red fog into chloride of silver, which in time will become black and ultimately spoil the negative. I would strongly recommend, therefore, where there is excessive density, red fog, or even too much detail in the shadows, that about a five grain solution of cyanide of potassium be flooded over the plate (preferably in a tray). Have ready in a glass measure a few scales of metallic iodine, into which you pour the cyanide; this will dissolve a portion of the iodine, and when the cyanide is again flooded over the plate the solvent action on the fog, etc., will quickly ensue. The moment the desired effect is obtained, the negative must be well washed. You will notice that I give the proportion of cyanide very weak; it is better to have it so. I employ the strength I am in the habit of fixing wet collodion with.

In conclusion, allow me to say we have a great power in emulsions. We have in two or three years (with only a few workers), produced in some respects better negatives than the many workers in collodion have done for the last twenty-seven years. What will the next twenty years bring forth? I hope to be amongst you to make comparisons.—*A. L. Henderson.*

* A communication to the weekly meeting of Photographers, London.

COMMUNION CUP, GILT, FROM THE DESIGN OF A. ORTWEIN, BY STUTTMANN, SILVERSMITH IN GRATZ.

GILT COMMUNION CUP.

THE effect of this communion cup rests principally on the harmony of proportion of its different parts and the delicacy of its profile and mouldings, but it is greatly enhanced by enameled incrustations and precious stones of different colors. The lower portion of the foot is set with emeralds alternating with pearls, the curved portion with rubies, and enriched with enameled medallions, in colors on blue ground; the knob also shows medallions, divided by rubies, which represent symbols of the Four Evangelists, and the Agnus Dei, in enamel on blue ground.—*The Workshop.*

HARD WOOD CHAIR.

THIS chair was copied from a 16th century design, with well proportioned details worthy of attention. The needle-

HARD WOOD CHAIR DESIGN, WITH HAND WROUGHT TAPESTRY COVER.

work upholstery has been substituted for the original stamped leather and heavy brass-headed nails of the older work.

SUMMER BEVERAGES.

LEMONADE.

PEEL off the yellow rinds from one dozen bright fresh lemons, taking care that none of the rind is detached but the yellow zest—that portion in which the cells are placed containing the essential oil of the fruit. Put these rinds into an earthen vessel, pour over them one pint of boiling water, and set aside in a warm situation to infuse. Express the juice from two dozen lemons, strain it into a porcelain bowl, and add two pounds of fine white sugar, three quarts of water, and the infusion from the peels. Stir all well together until the sugar is completely dissolved. Now sample, and if required add more acid or more sugar; take care not to have it too watery; make it rich with plenty of fruit and sugar.

LEMONADE, NO. 2.

To the juice of six lemons and the yellow rind of two lemons, add half a pound of sugar and one quart of water. Ice the lemonade. Water may be added according to taste afterwards.

ORANGEADE.

Pare off the thin yellow rind of four oranges and infuse in half a pint of boiling water. Express the juice of twelve Florida oranges and strain through a hair sieve; add to this three-quarters of a pound of fine white sugar, the infusion from the rinds and one quart of water. Ice the orangeade.

ORANGEADE, NO. 2.

Slice crosswise four oranges and one lemon; put them into an earthen jug with four ounces of lump sugar; pour upon these one quart of boiling water and allow to stand covered for one hour. Decant and ice.

CURRANT WATER.

To one pint of red currant juice and one gill of raspberry juice, add one pound of fine white sugar and one quart of water.

RASPBERRY WATER.

To one pint of raspberry juice add one gill of red currant juice, one pound of sugar, and one quart of water.

CHERRY WATER.

Bruise and rub through a hair sieve enough ripe cherries to produce a pint of juice; add to this one pound of sugar and one quart of water.

RASPBERRY VINEGAR.

Take any quantity of ripe red raspberries, place them in a stoneware jar and add white wine or pure cider vinegar just sufficient to cover them; cover the jar closely and set aside for five or six days in cool situation to infuse. Now remove the surface carefully and filter the liquid; add an equal quantity of sirup at thirty-six degrees of strength; mix well together, bottle and keep in a cold place. When used dilute with water or with any kind of aerated mineral waters.

SODA NEGUS.

Put one pint of port wine, with a quarter of a pound of white sugar, half a dozen cloves, and one quarter of a nutmeg grated into a saucepan; make it hot, but do not let it boil; pour it into a bowl, and upon the warm wine decant two bottles of soda water.

CHAMPAGNE A LA MINUTE.

Put into a pitcher or bowl two teaspoonfuls of carbonate of soda and about two ounces of finely powdered sugar; pour upon these one quart of sharp cider, and you have a very pleasant imitation of champagne.

ICED TEA OR COFFEE.

Make a strong infusion of tea or coffee; fill a pitcher or bowl with broken ice upon this; pour the infusion and sweeten to taste.

A COOL AND REFRESHING DRINK.

Put half a pint of lemon ice into a large goblet; pour upon this a bottle of soda or Seltzer water.

ORGEAT BEVERAGE.

Blanch one pound of sweet and one ounce of bitter almonds; put them into a stone mortar and pound them to a fine paste, with one wineglassful of orange flower water; then add and rub in by degrees, half a pint of rose water and a pint and a half of pure water. Strain through a hair sieve and add it to three pints of simple sirup; place it upon the fire and boil up for one minute, remove and bottle. A tablespoonful of this added to a tumbler of ice water, soda, or Seltzer, is a pleasant and refreshing drink.

HOLLAND BEVERAGE.

Make a rich lemonade or lemon ice, and to every three quarts add one pint of *the best* Holland gin.

IMITATION ARRACK PUNCH.

Two or three preserved tamarinds dissolved in a bowl of any kind of punch will impart to it a flavor closely resembling arrack.

SPANISH BEVERAGE.

To three-quarters of a pound of sugar and six ounces of pounded almonds, as for orgeat, add one pint of grape juice and three pints of water. Mix well together and filter. It should then be iced.

SPANISH BEVERAGE.

To three pints of rich lemonade add a bottle of claret and half a nutmeg grated.

PERSIAN BEVERAGE.

To one pint of strawberry juice add half a pint of rose water, half a gill of orange flower water, and one pint of simple sirup. Ice the mixture.

GERMAN BEVERAGE.

To one pint of orgeat sirup add half a gill of rum, one gill of Kirschenwasser, and a quart of Seltzer water. Now ice.

CLARET BEVERAGE.

To one quart of orange ice add a bottle of claret.

NARRANADA.

To four quarts of rich orangeade add two lemons and two oranges, cut into thin slices crosswise, and one pint of Schiedam schnapps. Mix well and ice.

ENGLISH RUMFUSTIAN, WINTER OR SUMMER.

Whisk well up the yolks of a dozen eggs, and add them to a quart of strong beer; to this is added a pint of gin. Put into a saucepan half a pound of loaf sugar, a grated nutmeg and a stick of cinnamon, and the yellow rind of one lemon. Pour over these a bottle of sherry wine; place upon the fire, and when the wine boils pour it upon the gin and beer; mix well and drink *hot*, or it may be cooled and iced.

WEST INDIA TIPPLES.

To a tumbler filled two-thirds with lemonade, add a wineglass of brandy, and fill to the brim with green lime juice.

To a tumbler of punch add a teaspoonful of extract of Jamaica ginger, and a little sirup or fine sugar.

To a tumbler of ice cold water add the juice of three ripe limes, and sweeten to your taste.

These are very refreshing and healthful beverages for the hot season.

IMPERIAL BEVERAGE.

Pare off the yellow rind or zest from one fresh lemon; add it to one quart of cream. Place upon the fire and bring it to the boiling point, stirring continually; now remove and continue to stir until quite cold. Sweeten with powdered sugar to your taste. Strain the juice of four lemons into a china bowl, pour the cream slowly upon the juice, holding the vessel containing it two feet above the bowl; stir well together, and let it stand two hours before using it.

MILK PUNCH.

To one quart of new milk add half a pound of fine white sugar, stir well together and mix in one gill of brandy and one gill of Jamaica rum. Grate nutmeg over the top, and ice.

BRANDY PUNCH.

To one pint of Cognac brandy, half a pint of Jamaica rum, and half a pint of peach brandy, add two pounds of white sugar, one gill of lemon and one gill of lime juice; mix all well together, and add ice equal to two quarts of water; cut two lemons into thin slices, peel and slice thin one pineapple, add these to the punch and let stand to ripen, and blend for one hour before using.

REGENT'S PUNCH.

Pare off the thin yellow rinds from four oranges and four lemons; express the juice from the same fruit and strain it; add to it the yellow rinds, with two sticks of cinnamon broken up, half a dozen cloves, and a dessertspoonful of vanilla sugar. Simmer these ingredients very slowly for half an hour in one quart of simple sirup. Express the juice from one and a half dozen of lemons, and add it to the decoction. Then make a strong infusion of the finest green tea and add it to the mixture; after which add equal portions of old Jamaica rum and Cognac brandy, according to the strength required. Mix all well together, strain through a hair sieve, put it into a freezer and make very cold.

PRINCE REGENT'S PUNCH.

Pare off the thin yellow rinds from two oranges and steep them in three gills of hot simple sirup for an hour; when this is cold add to it three gills of pineapple sirup, one pint of brandy, one pint of old Jamaica rum, one gill of Kirschenwasser, one gill of lemon juice, a teacupful of green tea, and a bottle of champagne. Mix these ingredients well together, put them into a freezer and half freeze them. Pour into glasses and serve.

CLARET PUNCH.

To a large punch bowl half filled with broken ice add two pounds of pulverized sugar; six oranges cut crosswise into thin slices, six bottles of claret, and one bottle of champagne; mix well together and let stand for one hour before using.

BISHOP.

To two bottles of claret add a quarter of a pound of loaf sugar, the thin yellow rind of an orange, and six cloves; make all hot, but do not allow it to boil; then strain it through a hair sieve into a bowl and ice.

HEIDELBERG BISHOP.

To a bottle of red Rhine wine add two ounces of lump sugar, the thin yellow rind of a lemon, a small stick of cinnamon, and half a dozen of coriander seeds and wineglassful of Kirschenwasser; warm all without boiling and strain; ice.

PRINCES' PUNCH.

Put into a freezing can a bottle of sparkling champagne, a gill of maraschino, half a pint of strawberry sirup, the juice of six oranges, the yellow rind of one rubbed on sugar, and a pint bottle of Seltzer water. Ice well and serve.

COCOANUT BEVERAGE.

To two grated cocoanuts with their milk add two quarts of pure water; place over the fire and boil for five or six minutes, stirring constantly with a wooden spatula; then strain through a hair sieve. Add to the liquid twelve ounces of pulverized sugar; mix well together and ice. This is a delightfully cooling beverage.

TURKISH BEVERAGE.

Put any quantity of fresh ripe grapes, picked from their stalks, into an earthen pan, cover them with boiling water and set in a warm situation for four or five hours to infuse, after which strain off the liquid, sweeten it to your taste, place in a freezing can and half freeze.

Grated pineapple prepared as above forms also a delicious beverage.

ICED COFFEE BEVERAGE.

Make one quart of strong coffee, to which add one pint of simple sirup; mix well and put into a freezer, and freeze just sufficiently to admit of its being poured into glasses for use.

CLARET BEVERAGE.

To one quart of orangeade add a bottle of claret and freeze as for iced coffee.

SHERRY BEVERAGE.

To one quart of rich lemonade add a bottle of sherry and freeze as above.

GIN PUNCH.

To half a pint of old Holland gin add one gill of maraschino, the juice of two lemons, and the yellow rind of one previously infused in the gin, two gills of simple sirup or four ounces of pulverized sugar, and one quart of Seltzer water. Mix well and freeze to a semi-solid.

SHERRY COBBLER.

Put into a pint tumbler a tablespoonful of pulverized sugar, one gill of sherry wine, a small slice of orange, the same of pineapple, and the sunny side of a ripe peach; then fill to the brim with crushed ice. Invert another tumbler of exactly the same size upon this, being careful that the edges fit closely together; grasp the two with both hands and shake rapidly together for at least one minute, then remove the upper tumbler, pile and heap ice crushed to a fine hail upon the cobbler; make an incision in the top of this ice, in which place a sprig or two of mignonnette, dust the ice slightly with rose colored sugar sand; decorate the rim of the glass with two or three roses, and at one side of the glass slip down to the bottom a large rye straw, to which apply the lips and commence to imbibe—and so, gratify the senses of sight, of smell, and of taste at one and the same time.

MINT JULEP.

This is made precisely in the same manner as the cobbler, except that you use brandy instead of wine, and you add to your fruits three or four sprigs of fresh spearmint. Decorate the top with sprigs of mint instead of flowers.

MEAD OR HONEY WINE.

Take ten gallons of water, two gallons of strained honey, with two or three ounces of white Jamaica ginger root, bruised, and two lemons cut in slices. Mix all together and boil for half an hour, carefully skimming all the time. Five minutes after the boiling commences add two ounces of hops. When partially cold, put it into a cask to work off. In about three weeks after working it will be fit to bottle. This is a wholesome and pleasant beverage, particularly grateful in summer when drunk mixed with water.

WEST INDIA SHRUB.

Take one gallon of Jamaica spirits, six pounds of refined sugar, and one quart of lime juice. Dissolve your sugar in the lime juice, and then mix it well with the spirits, after which put it into a demijohn to settle and become mellow. This will make excellent punch.—*Confectioners' Journal.*

TEST OF THE EYES BY ELECTRIC LIGHT.

PROF. COHN, of Breslau, has been lately making experiments with the electric light on the eyes of a number of persons for the purpose of testing its influence on visual perception and the sensation of color. He has found that letters, spots, and colors are perceived at a much greater distance through the medium of electric light than by day or by gaslight. The sensation of yellow was increased sixty-fold, compared to daylight; of red, six-fold; and of green and blue about two-fold. Eyes that could only with difficulty perceive and distinguish colors by daylight or gaslight were much aided by the electric light, and the visual perception was also much strengthened. Prof. Cohn concludes from this fact that electric light would prove exceedingly useful in places where it is desirable that signals should be seen at a great distance.

MICROPHOTOGRAPHY WITH TOLLES' $\frac{1}{75}$ INCH OBJECTIVE.

By EPHRAIM CUTTER, M.D.

IN his admirable report to the Surgeon General of the U. S. Army, on microphotography with sunlight, in 1871, Surgeon J. J. Woodward expressed the hope that others would carry out the idea he had inaugurated for demonstrating original work. The writer fully appreciates and acknowledges the great aid of his suggestions, and if I have ventured to modify his methods, it has been from the force of circumstances and peculiar obstacles to be overcome.

I think that my modifications have made the way plainer and have removed obstructions which the gentleman in question did not have to contend with. I may here remark that I can see no reason for preferring microphotography to drawing exclusively, or *vice versa*; there is no antagonism, micrology needs both methods. The history of the attempt at microphotography with the $\frac{1}{75}$ is as follows: In 1867, Dr. James H. Salisbury, of Cleveland, Ohio, had a work ready for the press on the causes and treatment of consumption based on 350 cases. In 1868 I became acquainted with it. Not to enter into details it is enough to say that a yeast in the blood is deemed to be the cause. It is found a year before organic disease. Dr. Salisbury killed 104 hogs by consumption artificially induced by yeast, and verified it by autopsies in all the cases. From my own knowledge the treatment based on this principle is successful beyond anything I have known before. In privately making these things known I was met with the greatest incredulity as to the evidence, which was mostly micrological. In order to sustain the position of my master I took Dr. Woodward's advice and resorted to microphotography. In my labors I was warmly and generously aided by Dr. G. B. Harriman, D.D.S., of Tremont Temple, and to this gentleman I give the full share of whatever credit may have been attained in photographing with Tolles' $\frac{1}{75}$ inch objective for the first time, not but that the morphology of consumptive blood could have been photographed with lower powers, but I desired to show those interested that in elucidating the views of one, who in my opinion has come nearer to the real nature of tubercle than any one before him, I had employed the best implements of precision that modern art has produced.

Conditions that were to be met.—1. It was necessary that the patient, the sun, and the apparatus with assistants, should all be together, because the blood must be withdrawn from the life stream and transferred to the sensitive plate in the shortest space of time. 2. The work must be done at different localities so as to have plenty of material to select from and to avoid disturbing elements. From these considerations it is easy to see that the Woodward plan of a dark chamber large enough to hold the operators and assistants could not be adopted, as it could not be carried about.

Fig. 1 is a drawing of my best apparatus. Scale $1\frac{1}{8}$ inch to one foot; the base is a black walnut $1\frac{1}{8}$ inch thick board, 55 by 11 inches; it is finished with the high polish of the piano maker's art so as to be insusceptible to warping from drying or wetting; running through the middle of it are two brass strips, 1 inch wide, $\frac{1}{8}$ thick, and $\frac{3}{8}$ inch apart. Beneath the contiguous edges is a deep furrow or groove, $\frac{1}{8}$ inch deep and $\frac{11}{16}$ wide. This is not shown in the cut; its object is to have all the apparatus move in one definite median line. At one end is seen the sun mirror, 10 by $8\frac{1}{2}$ inches, swung on two arms mounted on a swivel-jointed base; this allows of universal motion. Next is a standard mounted on a base that is attached to the brass groove by a "T" inverted below; the mirror has the same "T," the standard rises 15 inches in two grooved posts connected at the top, it is $8\frac{1}{4}$ inches wide; a set screw runs through one of the posts; in the groove a quinque-laminated veneer, $6\frac{9}{16}$ inches square, runs. In it is a hole, 4 inches in diameter, which admits a collar; in this collar slides an 18-inch Voigtlander photographic objective, about 3 inches in diameter; this is adjusted by the set screw in the side of the standard; next on the board comes the Tolles A microscope stand. The mirror is removed or turned out of the way, the stage is vertical, the $\frac{1}{75}$ inch objective is that on the stand; the eye-piece is removed and the open end of the microscope is pushed within the tube of the camera, whose lenses have been removed also. The camera is set up on a box in order to get the requisite height to bring the axis on a line with that of the microscope. The camera moves on the box and the box moves on the base. The three are connected as follows: a groove, $\frac{1}{4}$ inch wide and $\frac{1}{8}$ inch deep, is cut in the base exactly in the median line, and at right angles to the length. This is filled by a piece of ebony, $\frac{1}{4}$ inch to $\frac{1}{8}$ inch thick, and 4 or more inches long. A brass plate is let into the ebony so that when it is secured by screws it forms the bar of the inverted "T" before alluded to. When *in situ* this "T" slides under the baseboard brass strips. This arrangement is good, but don't stand travel by railroad. The same arrangement connects the mirror to the baseboard.

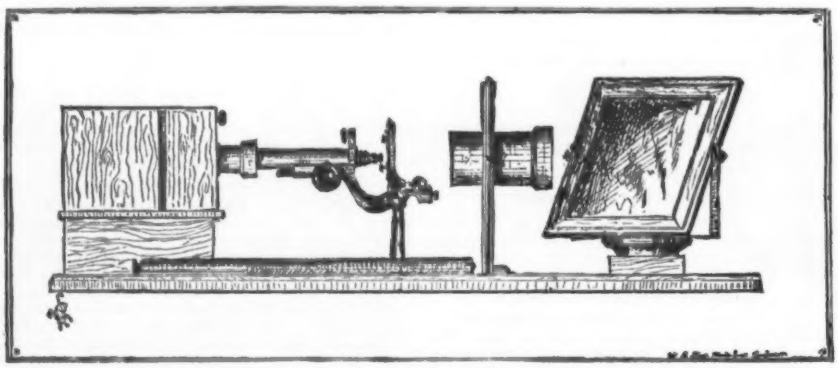
By the side of the camera is a rod, 26 by $\frac{3}{8}$ inches. Two screw eyes are let into the baseboard just at the ends of the rod. A screw runs through the eye into the right end of the rod, and another screw with a milled head goes through the other eye into the other end of the rod. The rod is thus secured and rotates by turning the milled head; 17 inches of the rod are covered with sand set like sand paper; in the cut this is covered by a sleeve of enameled cloth as the sand is detached by contact. When used the sleeve is pushed back and a braid or tape is run over the rod and around the milled head of the fine adjustment. A pin secures the ends of the tape when the proper tension is made by drawing them over each other. The delicate focusing is made by the hand of the operator while the eyes are on the ground glass plate of the camera; the tape is not shown in the cut.

Remarks.—It will be noted that the peculiar features of this arrangement which differ from Col. Woodward's plan are, besides the portability: 1, the size of the condenser; 2, the absence of the ammonio-sulphate copper or alum cell.

1. This condenser probably is the largest ever employed in microphotography. The reason of this selection was simply to avoid heat. It is easy to see that if a two-inch condenser is regarded as sufficient the same amount of light could be obtained with a three-inch, away from the heat focus, and thus avoid the effect of focusing the sun's rays on the object and the objective. This practical point has been of great value, and explains: 2, the absence of the contrivances to prevent the passage of destructive heat. Dr. Woodward has trouble with these cells, and, judging from lately finding him engaged in making a new form of cell for this purpose, it would seem as if this cell was a disturbing element still, though in the hands of the father of modern microphotography.

We have taken a large number of negatives, some of which have received honorable mention abroad—see *Journal de Micrographie*, Paris, October, 1877—and have used no device to cut off heat; hence we feel justified in saving ourselves the trouble of a, to us, unnecessary appliance. In our opinion this cell has stood in the way of the more general adoption of the reproduction of microscopic objects by photography. We think it is a good rule to use the simplest and fewest things to accomplish a purpose.

From what precedes it is seen how the $\frac{1}{75}$ inch objective was used for photography. The object, for instance, enlarged white blood corpuscles, was displayed on a slide by the sudden drying of a thin film of blood. The corpuscles were found by means of a low power and centered in the middle of the field. Next they were centered by a $\frac{1}{50}$ inch objective, then by the $\frac{1}{75}$. The microscope was then placed as shown in the cut, the eye-piece having been removed. The axis of the condenser, microscope tube, camera, and the center of the mirror were all ranged in one line. By means of the brass furrow in the baseboard the distances between them were changed without getting out of line. The sunlight, the chemicals, and all else had previously been found in working order by practical tests. Sunlight was thrown by the mirror through the condenser on the object, which was placed just beyond the heat focus. We found that the brightest and clearest days, before 3 P.M., were the best. One observer, with his head and the camera covered with a black cloth, noted the projection of the image on the glass-ground plate. Another fingered the fine adjustment, or it was done by the focusing rod. When the image was satisfactory a card-board cut off the light by interposition between the condenser and the object. The sensitized plate then replaced the glass plate and exposed, the regular exposure was made by lifting the card-board and letting it fall in the course of half a second or more. The time varies, and must be learned by trial. Usually it is shown by the action of the chemicals on the exposed sensitive film in the dark room. The processes afterward were those of the ordinary collodion process. It was necessary, of course, to look over the printing and instruct the printer how much exposure was needed.



APPARATUS FOR MICROPHOTOGRAPHY.

In photographing yeast in the $\frac{1}{75}$ inch objective the object was wet and covered with a film of mica. The following facts may not be out of place. It was made by Robert B. Tolles, at Boston, and delivered July 1, 1873. It was ordered by Dr. Harriman for the sake of working up his demonstration of the presence of nerve fiber in dentine. (*American Journal Dental Science*, May, 1870; *Dental Cosmos*, January, 1870.) Its angular aperture is 170 degrees; its actual opening on the face, $\frac{1}{64}$ inch. Cover adjustment moves about $\frac{1}{4}$ circle. Works wet or dry. Requires the aid of a powerful condenser. Usually it works best with a B eye-piece as a condenser under the stage, and with the thin edge of a common coal-oil flame shining "direct" into the condenser. It has to be used on a first-class stand whose stage is absolutely at a right angle to the tube. With this direct light the field is clear, white and flat. The objective is very sensitive to jars and motions. This troubled us much. We found in our experience that a cellar in a locality away from avenues of travel is the best place to work in. When an object is in focus with this objective, a gentle grasp of the arm that connects the tube with the trunnion joint (see cut) is sufficient to move the object out of focus.

The comparative excellence of this objective is not one for much discussion here; some have hastily said that it was of no value, not having used it, while others have looked at it with a sort of awe. In our opinion the question is not settled, though we think something toward it has been done. As far as our work has been concerned we know that we could not have attained our results with another objective, like the $\frac{1}{50}$ for instance, with the ease and facility with which we did with the $\frac{1}{75}$. While we feel sure that the practical clinical results of corroborating our study of consumptive blood can be attained with objectives of $\frac{1}{6}$ inch power—and it would be sad if it were not so—at the same time we are sure that no wrong has been done to any one by pressing the $\frac{1}{75}$ into our service. Moreover, if by our simple arrangement we have been able to transfer images with the highest power objective ever thus used, those who possess the low powers ought to be encouraged to use microphotography with the sunlight without condensing, or with the ordinary mirror, or with the B eye-piece.

Fig. 2 is a section of the writer's device for such work; it may be gotten up at a trifling expense. *a* is the tube of the microscope; *b* is a paper tube 30 by 2 inches. A nicely turned plug of wood adapts the microscope to the paper tube. To save space, the tube is broken off in the cut; a deal 8 by 12 by $\frac{3}{4}$ inches is seen in section, and fitted by a hole to the paper tube, *b*. *c* is a section of the ground glass

2.

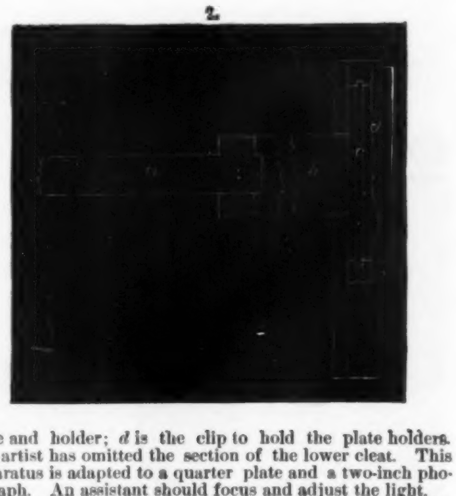


plate and holder; *d* is the clip to hold the plate holders. The artist has omitted the section of the lower cleat. This apparatus is adapted to a quarter plate and a two-inch photograph. An assistant should focus and adjust the light.

With these simple arrangements it would seem that the hope expressed at the outset of this article should begin to be realized.

Tremont Temple, Boston, April, 1879.

Postscript.—The first microphotograph of this objective may be found in the Yale College Library.

MUSK.

PROF. F. A. FLUCKIGER, in an article on the drugs at the late Paris Exhibition, says of musk: The musk-deer lives in Thibet, in Yün-nan, Sze-chuen, and also, but probably more sparsely, in Pe-tsche-li or Chih-li. According to *L'Année géographique* (1876, 476), Manchuria also furnishes it. According to F. v. Richthofen, the principal depot of the musk trade is the city of Ta-tsien-fu, in about 30° N. L., west of the Province of Sze-chuen.

The largest portion of the musk is carried to Shanghai by river, and finally reaches a somber hall in Billiter street, in the city of London, between Fenchurch and Leadenhall, which is the great entrepot of the civilized world for musk, ambergris, and civet. Here reigns the most expert connoisseur of musk, into whose hands all the firms who participate in Anglo-Chinese trade confide all the imported musk, so that the total available amount of it may be inspected or surveyed in this single room. Purchases of musk by perfumers or druggists are made through the special expert, who takes one pod after another out of the original package, and carefully examines each by inserting a slender knife-blade, without, however, really opening it. According to the result of this examination the pods are assorted; unless, which happens more seldom, whole original boxes, containing a few dozen pods, are purchased at once. The expert referred to mentioned to Prof. Flückiger that leather, blood, lentils, peas, and lead were the common fraudulent admixtures.—*Arch. d. Pharm.*

THE CARE OF YOUNG CHILDREN.*

THE diseases of children which cause the greatest mortality occur mainly during the hot months, or immediately thereafter, and are due largely to overcrowding of population in cities and thickly-populated parts of towns. They are much aggravated, if not directly caused, by filth of all kinds, especially by filth putrefying under the influence of summer heat.

Therefore infants and children should be taken, so far as it is possible, during the summer, to places where the air is clean and cool; if not to live in the country or at the seashore, then to parks, open squares, beaches, etc., for a day, or for as many hours at a time, and as often as may be. All sources of impure air in and about the dwelling should be avoided; the drainage should be carefully looked after; the water supply should be pure; no sink spouts should pour filthy water on the soil; there should be no untrapped sinks or drains, no stinking privy or pig-sty, no ill-arranged water closets, no arsenical wall papers, etc., to poison the air. Soiled clothing, diapers, etc., should be promptly removed from the rooms.

A baby should not sleep in the same bed with another person, and should have a plenty of fresh air, day and night.

FOOD.

Improper food is directly or indirectly connected with at least one-half of the deaths of young children. Of all the deaths under one year in Massachusetts, more than one-quarter are from diseases of the digestive apparatus, mainly of diarrheal character. Errors in diet cause also a vast number of deaths which do not show their real nature in the mortuary records; for instance, very many cases of "teething," "convulsions," "marasmus," "atrophy," "wasting," "hydrocephalus," etc., come under that head; and, furthermore, many cases of disease of the lungs, otherwise trivial, become dangerous because occurring in children previously weakened by indigestion.

The new-born child should, if possible, live altogether on the milk of its mother, or, failing that, of a perfectly healthy wet-nurse, unless, indeed, when the mother has not quite enough milk, the physician thinks best to supplement it with bottle-food. If neither the milk of the mother nor of a wet-nurse can be had, the milk of the cow or some other animal may be used instead; and this should be supplied fresh, night and morning—not necessarily from one cow.

Milk warm from the cow can usually be taken undiluted by infants of any age; if it has time to cool it should be

* From the recent circular of the Massachusetts State Board of Health.

thoroughly chilled immediately after milking, before being used for feeding infants.

Whether the baby be nursed or bottle-fed, the meals should be given at regular intervals during the day, every two, three, or four hours, according to the age and vigor of the child; during the night, only once or twice, for one or two months; after that, once or not at all.

The infant should not be allowed to go to sleep during its meals, but should be made to nurse continuously, except for occasional rests of a few seconds, until it has taken all it wants. By this means it soon learns to take just the quantity it needs; and, being neither hungry nor over-filled, it sleeps or lies comfortably between meals.

Crying should not always be considered a sign of hunger, and nursing out of meal-times should never be used to quiet the child.

Both breasts should be used at each nursing; and, when the milk has any tendency to be scanty, each breast should be given twice at each meal.

It is not always easy to tell whether a child gets as much milk as it ought. Not infrequently when the mother or nurse is losing her milk, and the child is obviously failing, it will yet seem to be satisfied at each meal, probably because it has learned not to expect more, and has ceased to hope for it. Then it suffers for want of sufficient food, and should, of course, be fed from other sources. Drawing on an empty breast, too, is in itself injurious to the child.

It may be said in general that the food which suits the mother will make good milk. It would be better to abandon most of the current popular theories as to what is or is not suitable for nursing-women. Perhaps the most objectionable one is that milk is indefinitely increased by taking large quantities of fluid. Certainly enough extra fluid must be taken to supply the extra amount demanded by the breast. Such vegetables and fruits as give the mother indigestion, or such as are found by experience, from some individual idiosyncrasy, to disturb the child without disturbing the mother, should be avoided; but, as a rule, the mother should eat what she usually finds conducive to her health.

It should generally be left to a physician to decide whether or not a mother is able to nurse her child. Mothers often think their child is not thriving on breast-milk, when the real difficulty arises from faulty habits of nursing, irregularity of meals, etc.

Cow's milk is usually, on the whole, the best material for supplying the place of the natural food. The constituents of cow's milk and of human milk are mainly water, casein, fat, and sugar, although not in the same proportions; but that is not the most important difference between the two milks, as may be seen when they are curdled. The curds of human milk are soft and flocculent; those of cow's milk become more and more hard.

Pure cow's milk is not often well digested by infants under six months old, nor always by older ones. The hard curds that it forms are often vomited, or pass through the bowels and appear in the discharges. It therefore becomes necessary to dilute it with water or some other material. When water is used it is commonly found best to give from one-third to one-half milk and from two-thirds to one-half water for the first month or six weeks, and then gradually to diminish the amount of water until at the age of six or eight months the milk is given without water. If the milk has been watered before it is bought, as sometimes happens, it may be given in larger proportion. These rules for diluting milk may only serve as a general guide; for all children have not the same powers of digestion, and some milks contain much more water than others. The greatest care should be taken that the water for diluting milk be not contaminated. If there be any suspicion of its impurity it is well to boil it, as some physicians recommend in all cases. As human milk contains a larger proportion of cream than cow's milk, it is usual to let the milk stand awhile, and take the upper part of it, after the cream has begun to rise. For a similar reason, sugar often is added to the diluted milk; usually ordinary cane-sugar, but sometimes by preference sugar of milk, on the theory that, resembling the natural sugar of the human milk, it will be less likely to cause indigestion.

If large curds are vomited or passed by the bowels, an alkali should be added to the milk (from two to five grains of bicarbonate of soda or bicarbonate of potassa, or from one teaspoonful to a tablespoonful of lime-water, in each bottle of food).*

The test of a method of feeding is the health of the child; and when, as often happens, children do not thrive well on milk simply diluted, there are several ways of preparing it that will usually make it more digestible. The principle is essentially the same in all—namely, to thicken the milk, and thus prevent the lumping of the curds. Barley, oatmeal, Graham meal, flour, arrow root, corn starch, rice, gelatin, isinglass, and gum arabic are all used in this way, and then all answer about the same purpose. They contain, it is true, some more, some less nourishment, but much less than the milk with which they are combined; so that their effect, when thus used, may be regarded as chiefly mechanical. The starchy parts of them are not absorbed by young infants, except to a very slight extent.

One of the best home-made preparations is of oatmeal. One tablespoonful of coarse oatmeal is left to soak over night in a quart of water. In the morning it is boiled down to a pint, and strained while hot. When cool it is of the consistence of jelly, and should be mixed with milk, generally in equal parts, only when about to be used. Pearl barley may be treated in the same way, and is preferable, if the bowels are relaxed.

There are many manufactured articles in the market, some of which are valuable and may be advantageously employed under medical advice.

Condensed milk sold in open cans is milk simply deprived of some of its water, and has the advantage over undiluted milk that it is less likely to sour in the thick state in which it is kept until ready for use. The taste of it is somewhat changed by the process of condensation, so that the flavor resembles that of boiled milk; but this does not seem to make it less easily digested or less nutritious. It should be diluted with rather less than four times its volume of water to make it equal to ordinary milk. It cannot be kept in warm weather more than three or four days.

The milk sold in sealed cans is condensed when fresh, and seems to retain the qualities of fresh milk for a very long period, unless it is diluted; so that, in spite of containing a great amount of sugar, the best preparations of it are sometimes useful.

Artificial food, when given, should be about blood warm.

Babies brought up by hand may take their food from a spoon, a cup, the so-called china duck, or from a nursing-bottle. The bottle has the advantage that the food is obtained by the natural process of sucking; the flow of the food is uniform and not too rapid. The spoon, cup, etc., have the advantage that they are more easily cleaned, and are decidedly preferable, if the nurse or mother will not use great care.

The bottle should be of the simplest possible arrangement. The best consists of a nipple of soft black rubber, with holes small enough to prevent a too rapid flow, snapped over the lip of a plain bottle with a tapering neck. It should contain eight ounces for young children and ten or twelve for older ones.

The bottle and nipple should be rinsed out in cold water, and then left entirely immersed in water until wanted for use again. If this is faithfully done no other washing is required. But if the milk dries upon the glass or the rubber, it sometimes cannot be removed except with carbonate of soda, scalding, and scrubbing. When thoroughness cannot be assured it is well to use a weak solution of carbonate of soda for rinsing regularly.

Tubes and joints are objectionable unless extraordinary care can be assured in keeping them clean; they should be put in a weak solution of common cooking soda, and be rinsed thoroughly before use.

WEANING.

The infant should be weaned in one of the cool months, not between May and October; it should be about one year old, not younger than nine nor older than fifteen months. It is very injurious for both mother and child to continue the nursing too long.

Long before the time of weaning the infant should have become accustomed to other food, in addition to the breast-milk; it should have learned to drink milk, or one of the preparations already mentioned, for one meal. At seven or eight months this may be varied by the addition of softened bread and by giving simple meat soup or beef tea. It is not particularly desirable to give to healthy children meals of concentrated soups or expressed beef juice, the true aim being not to crowd the child with nourishment, of which it can easily get enough, but to encourage a vigorous and natural digestion.

As the time for weaning approaches, the number of food-meals may be increased so that the child will be induced to give up the breast with very little difficulty.

Only simple food should be given, and at regular times, avoiding pies, cakes, unripe or over-ripe fruits, soothing sirups, patent medicines, etc.

BATHING AND CLOTHING.

The infant should be washed thoroughly all over every day once and during very hot weather twice.

For a few weeks the water should be at about blood-heat, or a little below it, from 98° Fah. down to 95° Fah.; and later, it should be lowered so that, at an age varying with the health and vigor of the child, the water should be warmed only enough to take off the chill.

It is better to put a baby into a bath of water than to bathe it in the lap; and the water should, if possible, be deep enough to cover it up to the neck.

When no bath tub is to be had, the best thing to use is the ordinary tin wash boiler.

The best way to avoid a chill after the bath is to wrap the child at once in a warm cotton sheet or towel, placed on a warm blanket.

The best clothing is that which is warm and at the same time light. Flannel is the best material for all seasons of the year, especially in the cool weather following the heat of August; infants are very susceptible to the influence of cold, and at that time they should be looked after with particular care. It is better that the bands of pinning blankets and skirts should be of flannel rather than cotton. Loose blankets and shawls that easily change their position on the body, or get forgotten occasionally, are undesirable garments. The shoulders, arms, and legs should be covered in cool weather, especially during the first four months; the stomach and bowels should always be carefully protected from cold.

Quite as much attention should be paid to keeping the child cool in summer as to keeping it warm in winter. Over heating is a common source of sickness.

NOTE.—Ridge's food, imperial granum, prepared groats, and prepared barley are manufactured articles, and the exact peculiarities of them are not known except that they are found to suit the digestion of many babies. As a rule they should be given in such proportion that the food, when ready for use, will pass easily through the nursing bottle.

Two preparations, Nestlé's and Gerber's lacteous farina, are exceptions to the above rule, and are real foods; that is, they really contain milk, but in a dried and powdered form. With the milk is supposed to be combined a powder of bread crust, which is rich in dextrin, a soluble substance resembling starch. Unfortunately these preparations, though very valuable forms of food, are quite expensive. It cannot be otherwise than a misfortune, also, that they are made by a secret process.

Horlick's (American) and Mellin's (English) food claim to contain all the constituents of Liebig's soup for babies, except milk.* They appear to be identical with each other, and are valuable as additions to milk.

* To make lime-water, put a piece of unslaked lime, as large as a hen's egg, in an earthen vessel, and pour on it slowly a gallon of pure cold water. After a few hours skim it, and pour off the clear fluid, which should be tightly corked in bottles.

* Baron Liebig's soup for babies, made of malt, flour, bicarbonate of potash and milk, is a very valuable food. It requires, however, more than half an hour's cooking every day, and its place seems to be fairly supplied by Mellin's and Horlick's food.

LOCAL ANÆSTHESIA BY CONGELATION.

DR. JAMES ARNOTT, in the *Medical Times and Gazette*, advises the more extensive use of local anæsthetics, and believes that in many cases the administration of anæsthetics by inhalation might thus be avoided. He claims that after congelation the tissues are in a condition incompatible with inflammatory changes, and he knows of no instance of erysipelas following the proper use of congelation. He much prefers the application of a mixture of ice and salt, in a muslin bag or otherwise, *with pressure*, to the ether spray, finding it more rapid and less painful. He uses in small operations a piece of ice repeatedly dipped in salt and applied to the part to be frozen. In other cases, a mixture of one part by weight of salt with two of crushed ice is recommended. The experience of Professor Gosselin, of Paris, is quoted, he having used a freezing mixture of equal parts of ice and salt in fifty-four cases of operation for evulsion of the toe nail.

NATURE OF COHESION AND ITS CHEMICAL SIGNIFICANCE.

By FRIED. MOHR.

AMONG all the properties of matter cohesion is the most universal in its manifestations and yet the least regarded. We are so accustomed to perceive all things in a certain state of cohesion, that we cannot separate this attribute from the essence of things, whence it happens that it has been treated as the Cinderella of physics, and seems as it were placed outside the law of the conservation of force. An attempt has been made to explain the phenomenon by means of the attraction of the smallest particles, and to bring this attraction into connection with the universal attraction of the heavenly bodies, which is also merely an assumption. It is plain that cohesion is a true force which can be measured by the sum total of the force required to overcome it. We must endeavor to bring this cohesive force in connection with the other accessible and known forces according to the laws of mechanics. The force most readily to be connected with cohesion is heat, because we know that heat can overcome cohesion. We must seek to understand how heat—which we rightly consider as an internal movement in substances—exists in such substances, and for this purpose the theory of waves offers us the needful points of approach.

After summarizing the characteristics of undulation, and distinguishing progressive and stationary waves, the author proceeds:

Cohesion is not due to thermic vibrations; as, on the contrary, heat annuls cohesion. A second force must, therefore, be present which produces the phenomena of cohesion. Thermic vibration has merely served to explain the mechanism of internal motion.

The existence of a second force or movement present in all bodies, and essentially distinct from heat, is inferred from the heat which appears on chemical combination. We must always remember that force is never created or annihilated, but that in all cases there occurs merely a modification in the form of the movement, but not in the sum of the *vis viva*. If, therefore, heat appears in any chemical process, it must have been present in the reacting matter in some other form—as motion which is not heat. For storing up a great force in a small quantity of substance no other form can be found save that of stationary waves, which cannot become progressive; and in solids we assume a vibration much smaller than that of the heat waves as regards its volume, but much greater as regards the number of the waves. For this movement I proposed, in 1868, the name "chemical motion," or chemical wave.

We see everywhere that heat overcomes cohesion, and in so doing disappears as heat. This state has been termed latent heat, though we must remember that it is no longer heat, but a movement of another kind. If mechanical power is produced by heat, such heat likewise becomes latent, and the movement of masses, like the thermo-electric current, may be called latent heat.

A proof that a great sum of *vis viva* exists in bodies, in addition to heat, may be given experimentally by means of the calorimeter.

The author adduces experiments in proof of this proposition, and continues:

Everywhere cohesion is modified by chemical processes, and inversely in every chemical process a change of cohesion appears.

After considering the action of cement, solders, and of the apposition of smooth, clean, homogeneous surfaces, Dr. Mohr continues:

Between cohesion and adhesion there is no difference; cohesion was sometimes said to exist between similar, and adhesion between dissimilar bodies. If a thick solution of glue is dried up in a porcelain capsule, pieces of the latter may be broken if the glue is removed forcibly. Here adhesion is stronger. Cohesion is a decidedly chemical property, and can be overcome by chemical means. Solution is the fusion of a solid body in one already melted. In the latter its peculiar molecular motion, which determines its chemical attributes, has been already overcome or modified by an excess of heat, a part of which has apparently disappeared as such, and has been converted into another form of movement. The excess of heat still suffices to overcome cohesion in another body, and thus again a certain quantity of heat disappears as such. Latent heat is not heat, but a new chemical attribute. The 79 heat-units which a weight-unit of hot water at 79° conveys suffice to overcome the cohesion of one weight-unit of ice at 0°, and to convert it into water at 0°, and as long as the water remains liquid no other free heat is present than that which belongs to it as water. But as soon as the water is made to freeze, 2×79 heat-units escape, and there remain two weight-units of ice at 0°. This leads us directly to the connection between hardness and fusibility. The latter is decidedly a chemical attribute and their connection secures the same rank for hardness. The metals form a scale of hardness almost in accord with their fusibility. The fats form two parallel scales of hardness and fusibility from white wax to oil of almonds.

It has been already shown that cohesion consists essentially in the perflux of the stationary waves of that movement which permanently determines the chemical attributes of bodies, and we distinguish the permanent non-communicable movements from the transient movements of free heat. Every permanent action of heat which reveals itself by a change of cohesion is attended by a permanent change of the chemical nature. (?)

Cohesion and affinity being closely connected, we are led to consider more closely the views on affinity. The ordinary doctrine is that affinity exists only between bodies which are chemically different. This is correct if we rank among the manifestations of affinity merely such processes as are attended with explosion, ignition, or the production of a strong heat. But it seems that we might exactly invert this proposition, and, as in the animated world, assume affinity among like bodies, if we suppose that the mobility of bodies depends on heat. Thus water unites with water in every proportion without any perceptible physical phenomena. But water with its 88·9 per cent. of oxygen has no affinity for liquids poorest in oxygen, such as benzol and petroleum. Ethereal oils dissolve in water almost proportionally to their percentage of oxygen, and phenol is tolerably soluble. Potassic chloride and iodide, ammonic chloride, etc., dissolve in water, on account of the analogy between chlorine, iodine, and oxygen. Between water and fats there is not even adhesion or moistening. The internal movements are respectively so heterologous that the wave-systems cannot pass into each other; on the other hand, liquid oils adhere to solid fats, as does mercury to gold.

It was observed that certain chemical bodies can be mutually substituted for each other in crystals without a change of form. This fact was named isomorphism. When it sub-

sequently appeared that the atomic volumes of isomorphous bodies were equal, the idea of isomorphism was transferred from the crystal to the atom, it being assumed that the substitution was explained by the equal size and similar shape of the atoms. Thus sulphur, selenium, chromium, and manganese appeared isomorphous on account of the acids RO_3, and manganese and chlorine on account of the acids R_2O_7. If isomorphism depends on the identical form of the atoms, chlorine must be isomorphous with sulphur, selenium, and chromium. This is not the case, and the assumption is therefore false. Sulphur has two crystalline forms differing in specific gravity, and consequently in atomic volume, which is atomistically impossible and unthinkable. The acicular sulphur when it passes into the rhombic form by comminution evolves heat, and on burning evolves 41 calories more than does the rhombic variety, so that this heat must have entered into crystallization. The assumption of the equal shape and size of atoms is therefore untenable.

Our modern theoretical chemistry depends entirely upon the atomic hypothesis, *i. e.*, it is assumed that the elements consist of smallest particles not further divisible, and hence called atoms. On this point we have neither direct observations nor experiments. The assumption is made in order to explain the fact, a thousand-fold confirmed, that the elements always combine with each other in definite ponderable proportions, and that if two elements form several combinations, their proportions are small multiples, not exceeding the number 7. In fact the atomic theory explains this phenomenon satisfactorily, but nothing more, and great modesty has been shown in endowing these atoms with properties, because important mechanical difficulties cropped up on all sides and weakened the indispensable proof for multiple proportions. We have no idea of the form, the color, the magnitude of these atoms, and we have merely deduced their relative weight, their relative volume, and their specific heat. Our monistic conception of nature leads us to apply to atoms our view as to the cohesion of bodies, since the assumption of indivisibility must find its ultimate basis in cohesion only.

The magnitude of the atomic weights has been deduced from analyses, leaving merely the uncertainty whether a single or a double weight must be admitted, according as we proceed with or without Avogadro. The atomic volume equals the atomic weight divided by the specific gravity, and the atomic heat is the product of the specific heat and the atomic weight.

The calculations founded upon these propositions depend on the assumption that the specific gravity of the atom is the same as that of the mass. The discussions concerning atomic volumes are well known. According to the experience that the atomic weight of a compound may be found by adding up the atomic weights of its constituents, we might imagine that the atomic volume of a compound would be calculable in a similar manner. This, however, is never the case. The specific gravity of the individual constituents is never the same in the compound as in their free condition, but expansion or contraction always ensues. The compound never occupies the same space as its constituents. Carbonic bisulphide occupies 41 per cent. more space than its constituents. Its specific gravity, calculated from that of carbon and sulphur, should be 2·152, but it is found to be only 1·272. Consequently atoms have to be accredited with a power of expansion or contraction according to circumstances. The calculation of the atomic volume presupposes that the atom of silver possesses the specific gravity of a mass of silver (10·428). We must, then, also assume that it has the luster and the opacity of massive silver, not to speak of hardness, because it is indivisible. If we once assume atoms we must grant them not merely indivisibility, but also immutability, and it is then inconceivable how we can see through melted nitrate of silver which contains by weight 63 per cent. and by volume 6 per cent. of metallic silver. The mercury atom must be a minutest granule of mercury, and equally opaque as mercury in bulk. Concerning carbonic acid and ether, we know that if heated in strong glass vessels they disappear, and yield a vapor almost of the same density as the liquids themselves. If we assume this to be the case with mercury, the absolutely transparent and invisible vapor of mercury would have nearly the specific gravity 13. This fact, and indeed the changes of all bodies by mere heat, is on the atomic theory incomprehensible. A different arrangement of the atoms cannot possibly deprive them of all their attributes.

The atomic theory meets with its greatest difficulties in the gases. It is necessarily assumed that the atoms of hydrogen, oxygen, etc., are solid, massive, indivisible bodies. The specific gravity of these atoms cannot be determined, since heat and pressure cannot be removed from them. Most of these gases are absolutely invisible, and according to the analogy of mercury and zinc, it would be possible that such atoms also may be of an opaque, metallic nature. But the liquefaction of the permanent gases, lately so-called, yields colorless liquids, which, indeed, like water, are invisible by transmitted light. The atomic theory is compelled to assume that the gases move as distinct particles in an absolute vacuum. But then we cannot understand how light can penetrate. The optical ether is no more a matter of demonstration than the atoms, and, as we deny its materiality, it cannot be the substratum of a force. The gas theory of König and Clausius is a rather bold attempt to explain the existence of gases; but it cannot maintain its ground even on mechanical principles. It is assumed that the absolutely elastic gas atoms move with equal speed in a rectilinear direction, and rebound from the sides of a vessel. At the same time they vibrate in all directions. It is mechanically inexplicable that a body moving in a certain direction should ever change its direction without some external influence. The individual atoms must share among themselves the function of vibrating in different directions.

If in a cubic meter of empty space there is one cubic millimeter of hydrogen gas, there must be spaces perfectly void. The nature of gases is inexplicable, unless we consider the matter of the gases as continuous and perfectly elastic, whereby the empty spaces are done away with. This applies to all bodies which can assume the gaseous state or can combine with solids according to the law of multiple proportions, *i. e.*, to all the elements without exception. The atomic theory fails to explain the changes produced in bodies by heat alone; the difference of properties in compounds and in their constituents; the liberation of heat which accompanies combination, and its disappearance during fusion and dissociation; it does not explain allotropisms, colors, states of cohesion; in a word, it explains nothing save the uncontested fact of combination in definite proportions.

Atoms which according to theory are solid bodies must have a shape. On this subject nothing has been observed. As the most natural conjecture the sphere has been assumed as the most regular of all forms. But in pursuance of another theory the existence of molecules has been inferred, *i.e.*, combinations of from two to six atoms forming one common body, and it is conjecture that the gases in a free condition consist, not of single atoms, but of molecules each formed of two atoms.

For this view we have no proof save its agreement with a hypothesis itself incapable of demonstration. It cannot be shown how the tendency of the individual atoms towards union can be satisfied by any particular number, since between two individual bodies, *ex hypothesi* absolutely identical, no compensation of different forms of motion can take place. We are unable to say whether a mass of silver or copper is comprised of atoms or molecules. Two spheres can touch each other only at one point, and, as we have shown above, no notable cohesion can thus arise. The spheres have also been invested with absolute elasticity, without which the permanence of a gas cannot be thought. If we wish to assume that these spheres flatten each other, and thus offer a larger surface of contact, there can be no reason advanced why the atoms should press so closely together. A body consisting of spheres must necessarily contain empty spaces, into which the finer atoms of gases, such as hydrogen, may penetrate. But not a single fact supports this view (?); and we must, therefore, assume that massive bodies completely fill the space which they occupy.

The origin of a body continuously filling space, as the doctrine of atomic volumes demands, presupposes atoms as bounded by plane surfaces.

The strong cohesion of solids compels us to assume that their mass is continuous, and at the same time elastic, so as to receive the waves of thermic and cohesive movement. If we sum up in brief our results, they may be formulated as follows:

1. Cohesion depends on pervading stationary waves of a particular form of motion, which at the same time determines the chemical properties of bodies. These waves are not directly transmissible.
2. Heat is another form of movement with both progressive and stationary waves, which can be communicated from one body to another.
3. In the chemical union of two bodies a part of the chemical movement is eliminated as heat, or heat is taken up as chemical movement. In the former case there is an increase of cohesion, and in the latter a decrease.
4. Heat is everywhere present in the free state, and everywhere it diminishes cohesion.
5. The quantity of *vis viva* which dwells in any substance as its chemical quality exceeds the free heat immensely.
6. Solids have unchangeable nodal planes and stationary semi-waves at their boundaries. Liquids have movable nodal planes.
7. Vapors are gases from which the chemical wave-movements are easily separated as heat. Gases are vapors from which these movements are not readily separable, the difference being merely one of degree.
8. All the phenomena of cohesion can be reduced to vibration.
9. Allotropic forms are distinguished by unequal quantities of chemical movement, and of the accompanying differences in cohesion, as proved by unequal heats of combustion.

The facts of definite proportions and of small multiples must find a new explanation, and if the suspicious word "atom" is to be avoided, we may speak of combining weights. The law of Dulong and Petit, of the equal atomic weights of the elements, though not thoroughly carried out, does not depend upon accident, and must have a real basis; likewise the fact of similar atomic volumes in bodies chemically similar. The further fact must be recognized that the gases combine in simple proportions, and that their combining weights coincide with their specific gravities. The magnitudes of our atomic weights will also not be influenced by a new theory.

The laws of wave movement are the same for the revolution of worlds, for the waves of water, the pendulum, the vibrating string, for sound, light, heat, and cohesion.

As the phenomena of cohesion and the chemical properties of bodies therewith coincident depend on the transit of waves, the long recognized fact becomes intelligible that chemical action ensues only on the immediate contact of the bodies, that the phenomena of affinity do not depend on a specific attraction, and that there can be no question of a static of atoms. Chemical combination is the act of assimilation of different systems of waves, and it is the more intense the more they differ in their qualities.

After chemical combination the two bodies interpenetrate each other completely, and possess one and the same wave-system, but different from the systems of their free condition.

As the color and hardness of bodies are consequences of their inner wave movements, the change in the properties of the new compound are easily explained by the elimination of movement in the shape of heat.

Dissociation is the rupture of a chemical compound by heat which is permanently introduced as chemical movement and becomes latent. One at least of the constituents must be gaseous or be capable of becoming so.

The explanation of definite combining proportions by means of the atomic theory was, further, very difficult, and was not reached without some *sacrificio dell' intelletto*, which, however, was overlooked, as the consequences were not inferred. On attempting to bring cohesion within the law of the conservation of energy all this came to light, in addition to the inexpugnable mechanical difficulties which cling to the idea of the atom. Along with atoms must fall their enumeration, their catenation, their position, the molecules and their "splitting," the structural formulæ, the types, the rings, the unities of affinity, and the whole atomistic *cancan* as at present in vogue. Modern chemistry has placed herself outside the law of the conservation of energy; she accepts the heat of combination as a free gift without asking its origin; she explains the different properties of isomeric compounds by a different position of the atoms, though such compounds display different combustion-heats, and from position alone no movement can arise. Lothar Meyer's ingenious syllabus of modern chemical theories begins with the sentence: "The foundation of all at present prevailing chemical theories is the atomistic hypothesis," and the burning question of the combustion-heats is not noticed in a single syllable; not even the feeling of the need of an explanation of this the most important of chemical processes can be traced. If based upon a false foundation science can make no valid advances, and explanations turn now upon hypotheses rather than upon nature. In due time an explanation of the law of multiple proportions, based upon the theory of undulations, will be found, and instead of a proud *ignorabimus* we shall have modest *ignoramus*, or even a hopeful *inveniemus*.

The foregoing representation is indeed merely like a blow on water, which stirs up a few ripples, but no persistent ones. It is easier to agitate atoms than to shake the faith in them, and I hear many a voice exclaim: "Disturb not my structure formulæ; are all the time and labor expended in making them look like something real to be wasted? or can you give us a new faith in place of the old?"—*Chemical News.*

CHLOROPHYL.*

By E. FREMY.

UNDER chlorophyl, I mean the green matter as found in leaves, and so named by chemists. It must not be mistaken, however, for the chlorophyl of the botanist, which is a living organism.

Of what constitution, then, is this peculiar matter, which, during the period of the life of the plant, seems to take an active part in the decomposition of the carbonic oxide through the leaves, and which, on account of its peculiar characteristics, may be compared with the *materia rubra* of the human blood? Is it to be looked upon as a simple part, or as a mixture of a blue or green with a yellow substance?

If this chlorophyl is composed of two different matters, as I will endeavor to show, what are its chemical properties? Are they neutral, acid, or of a basic or saline nature? Do they originate from one and the same substance, differently modified by vegetation?

These questions, so highly interesting to vegetable physiology, are still shrouded in mystery, which I am endeavoring to unvail through my investigations; but the difficulty of the obstacles to overcome permitted me to make but slow progress.

The late communication from Guillemare & Lecourt, on the coloring of the husk of the fruit of leguminous plants through chlorophyl, induced me to try new experiments regarding the constitution of this peculiar matter, in order to explain observed facts.

My previous studies on chlorophyl tended to prove that it was not a simple coloring matter, but composed of two different substances, viz., a yellow, which I named phylloxanthin, and a bluish green, named phyllocyanic acid.

I based these facts upon the following experiments:

1. Treating green leaves with alcohol of various strength, I found that an alcohol of 60 per cent. would only extract a yellow matter (phylloxanthin), while the phyllocyanic acid would remain in the parenchyma and only darken the leaves in appearance. To exhaust, then, the phyllocyanic acid, 70 per cent. of alcohol was necessary.

2. A similar trial on the chlorophyl lake (ppt. of chlorophyl by alum), which in this case undergoes the same changes as the cellular tissue of leaves, leads to the same results, viz., a 62 per cent. alcohol would only take up the phylloxanthin, whereas stronger alcohol would extract the other matter. Thus so mild a solvent as alcohol is capable of separating the chlorophyl into two different constituents. Acid and basic reagents proved the above observations, and permitted a more remarkable separation.

3. By treating the alcohol solution of chlorophyl with hydrochloric acid and ether, the latter will take up the phylloxanthin, assuming a yellowish color, whereas the phyllocyanic acid will be taken up by the hydrochloric acid, imparting a beautiful bluish color to the same.

To make this experiment a perfect success, the hydrochloric acid, diluted with its own volume of water, is to be added first, and then the ether.

4. Upon the addition of a few drops of baryta water to an alcoholic solution of chlorophyl, the phyllocyanic is precipitated in combination with barium, which is insoluble in alcohol, changing the same to a nice golden yellow color, due to phylloxanthin in solution.

I then tried to ascertain in what condition these two constituents of chlorophyl exist in the organic tissue. Are they merely mixed or combined? Are they suspended in the liquid or united with the cellular tissue?

In my last communication I stated that these two coloring matters of leaves were united, and compared their separation through baryta or lime to a kind of saponification. Now, however, I am inclined to believe that they exist in the leaves as a mere mixture.

There yet remained to be ascertained whether the phyllocyanic acid in the leaves existed in a free state, or combined with a base, or united with the cellular tissues by a kind of capillary affinity. For this reason I tested the alcoholic tincture of green leaves for the presence of mineral bases, and, to my surprise, found a notable quantity of potassium, the quantity increasing with the darkness of the color. The residue obtained by evaporating the tincture yielded, after incineration, a tolerably pure carbonate of potassium. The green matter of leaves, then, can be considered as a phyllocyanate of potassium.

But to arrive at this conclusion from the observed facts, it was not sufficient to merely prove the presence of potassium in the alcoholic tincture, as other organic potassium salts may be contained in the solution; it was, therefore, necessary to combine the phyllocyanic acid with potassium, to show that this compound corresponded with the green matter of leaves. In that I met with a serious difficulty, as I have not to the present time succeeded in obtaining the phyllocyanic acid in a free and pure state. Acids decompose it, producing a brownish substance, which suggests some analogy to hæmatin, which also is destroyed by acids.

Fortunately, this difficulty was overcome by a double decomposition between phyllocyanate of barium and sulphate of potassium. This process in an alcohol solution resulted in the formation of phyllocyanate of potassium in solution, as indicated by its strikingly beautiful green color and the precipitation of barium sulphate. Sodium and ammonia sulphates produced similar results.

By comparing the phyllocyanate of potassium with the green matter of leaves the identification was fully manifested. Both dissolved in alcohol, ether, and solution of carbonic acid, with the development of the green color; decomposition by acids resulted in a brown substance, and the alcoholic solution afforded a precipitate on the addition of baryta, lime, or solution of subacetate of lead. In the spectroscope the phyllocyanate of potassium, like the chlorophyl, gives the characteristic black absorption band in the center of the red portion of the spectrum.

Meanwhile I noticed a peculiarity which would seem to distinguish the chlorophyl from the phyllocyanate of potassium, namely, the latter is soluble in alkaline water, while the same menstruum does not extract the green color from

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the leaves. This difference, however, is easily explained; in the leaves the green matter is united with the parenchyma by the aid of capillary affinity, and this union or combination is not broken by water, but by a sufficiently strong alcohol.

The following experiment gave an apparent verification. Fibers of cotton and linen immersed in a solution of phyllocyanate of potassium united with the coloring matter; the latter was not re-extracted by water, though by alcohol and ether, as in the case of green leaves.

Therefore—to recapitulate the results—it is a proven fact, that the coloring matter of leaves is a mixture of phylloxanthin and phyllocyanate of potassium.

It has long been known that leaves in autumn generally lose their green appearance, changing to yellow, and also give off a large portion of their alkali. Now we know that this process depends upon the decomposition of the phyllocyanate of potassium.—*Pharmacist.*

CHEMICAL COMPOSITION OF MINERAL COAL.

Abridged from *Comptes Rendus* for the *Franklin Journal* by PLINY EARLE CHASE, LL.D.

FOR nearly thirty years Prof. E. Fremy has been studying vegetable tissues, with especial reference to the chemical nature of the principles which they contain, and the influences which have changed them into lignite, bituminous coal, and anthracite. He began with examining the vegetable skeletons. The substances which he first studied were almost wholly unknown; their characteristic property is their production, under the influence of a ferment or of reagents, of gums and gelatines. He showed that they are all derived from a primitive insoluble compound which he called *pectose*, represented in its greatest simplicity by the formula $C_8H_5O_7$, and which by successive polymeric transformations, forms at first gummy substances, then gelatinous bodies, and finally an acid soluble in water.

He then began the study of the stable elements which form the fibers, cells, and vessels. He found that the vegetable framework is not so simple as he thought; it is not built up of simple cellulose differently incrusted by other substances, but of many kinds of isomeric cellulose. There is also in nearly all parts of the skeleton a very important body which differs from the celluloses in composition and properties, which abounds in the vessels, and which he therefore calls *vasculose*. The proportions in which it exists in different kinds of wood affect their physical qualities. Oak may contain 30 per cent.; in walnut shells there is sometimes 50 per cent. It binds the woody fibers together. Caustic alkalies dissolve it, and they are therefore employed in the manufacture of wood paper.

After ascertaining the composition of the internal tissues, he analyzed the cuticle and other coverings, discovering *cutose*, which is well fitted, by its resistance to chemical change, for protecting the parts which are exposed to the air.

Passing next to the bodies which are most often found in the tissues, he showed that gum is a true salt of lime, and that chlorophyl owes its green color to a salt of potash.

In extending his studies to combustible fossils, he first sought what chemical differences characterized wood, peat, the different lignites, bituminous coal, and anthracite. He found that wood is not sensibly attacked by a dilute solution of potash, while peat often yields to that alkali considerable quantities of ulmic acid; xyloid lignite, or fossil wood, still contains notable proportions of ulmic acid, but it is easily distinguished from wood and peat, because it is changed into yellow resin by nitric acid, and it is completely soluble in hypochlorites; compact or perfect lignite contains no appreciable ulmic acid, and still it is dissolved in nitric acid and the hypochlorites; as to the true coals, they are characterized by their insolubility in neutral solvents, acids, alkalies, and hypochlorites.

In his synthesis he was guided by the experiments of Daubrée and Baroullier, which indicated the importance of heat and pressure in coal metamorphosis. He performed a series of experiments, in which vegetable tissues and the substances which most often accompany them in organization were separately kept for a considerable time, at temperatures from 200° to 300° (392° to 572° F.), in hermetically sealed glass tubes. He found that cellulose, vasculose, and cutose all become black, brittle, yielding water, acids, gas, and tar, but preserving their organization; they did not melt, but gave a fixed product which showed no resemblance to mineral coal. With sugar, starch, gum, chlorophyl, and the fatty and resinous bodies which accompany it in the leaves, the results were very different. By long calcination under pressure they became black, shining, often melted, absolutely insoluble in the tested chemicals, and very different from charcoal, for when heated to redness they behaved like organic bodies, yielding water, etc., but having as a fixed residuum a hard and brilliant coke. The chemical resemblance to a specimen of Blanzy coal, which was analyzed by Regnault, is thus shown:

	Carbon.	Hydrogen.	Oxygen.	Ashes.
Coal from sugar	66·84	4·73	28·43	—
" " starch	68·48	4·68	26·84	—
" " gum arabic...	78·78	5·00	16·22	—
Blanzy coal....	76·48	5·23	16·01	2·28

He was induced to experiment on these three substances because, according to Ad. Brongniart, they must have abounded in the vegetables which produced the coal beds, and because gum often comes from the transformation of tissues, as Trécul has shown.

Further experiments led him to the dominant hypothesis that vegetables are first changed into peat, and that in that form the disappearance of the organized tissues is due to a kind of turfy formation, as Van Tieghem suggested. He then operated on three kinds of ulmic acid: 1, acid which he had himself extracted from peat; 2, saccharulmic acid, which he obtained from M. P. Thenard; 3, ulmic acid extracted by treating vasculose by alkalies. They were all transformed into substances similar to the foregoing, under the combined influence of heat and pressure, as is shown by the following analysis:

	Carbon.	Hydrogen.	Oxygen.
Coal from peat acid, heated 24 h...	67·48	5·84	26·68
Same, heated 72 hours	71·72	5·03	23·25
" " 120 "	76·06	4·99	18·95
Coal from vasculose acid..........	76·43	5·31	18·26

Finally he examined the modifications, under heat and pressure, of mixtures of chlorophyl with the fatty and resinous bodies which alcohol extracts from leaves. Although the mixture was at first soluble in alkalies, after 150 hours' treatment it gave a black substance, viscous, insoluble in caustic alkalies, and presenting an evident analogy to natural bitumens.

ON THE SIZE OF MOLECULES.

By N. D. C. HODGES.

IF we consider unit mass of water, the expenditure on it of an amount of energy equivalent to 636·7 units of heat will convert it from water at zero into steam at 100°. I am going to consider this conversion into steam as a breaking up of the water into a large number of small parts, the total surface of which will be larger than that of the water originally. To increase the surface of a mass of water by one square centimeter requires the use of 0·000825 milligramme of work. The total superficial area of all the parts, supposing them spherical, will be $4\pi r^2N$. The number of parts being N, the work done in dividing the water will be $4\pi r^2N$. For the volume of all the parts we have $\frac{4}{3}\pi r^3N$. This volume is in accordance with the requirements of the kinetic theory of gases, about $\frac{1}{3000}$ of the total volume of the steam. The volume of the steam is 1,752 times the original unit volume of water.

$$\text{Hence } \tfrac{4}{3}N\pi r^3 3000 = 1{,}752$$
$$4N\pi r^2 \cdot 000825 = 636{\cdot}7423.$$

One unit of heat equals 423 milligrammes.

Solving these equations for r and N, we get r equal to 0·00000005 centimeter, a quantity of the same order of magnitude as has already been obtained by Thomson, Maxwell, and others, N equal 9,000 (million)^3n for the number in one cubic centimeter 5 to 6 (million)^3.

Around every body there is an atmosphere of more or less condensed gases. On the surface of platinum these must be nearly in the liquid condition, as shown by the power of platinum to bring the atoms of hydrogen and oxygen so near together that they combine. These vapors on the surface have a tendency at ordinary temperatures to expand; and part of them can do so, if the surface of the body is reduced. There is in these condensed atmospheres an explanation of all the phenomena of superficial tension. The energy in the unit of area ought to be equivalent to the amount of work done in compressing a quantity of the vapor from the gaseous to the liquid state sufficient to cover the surface a few molecules deep. The molecular attraction seems to be very slight in gases, when the molecules are ten to fifteen molecular diameters apart. To get some idea of the amount of work done in compressing one gramme of oxygen to liquid form, we may consider that in the union of one gramme of hydrogen with eight grammes of oxygen 34,462 units of heat are produced. It matters not that the condensation is brought about by the energy of chemical separation rather than by the work done in pressing them together in a cylinder.

The superficial energy of platinum is 169·4 milligrammes per square meter, or 0·01694 per square centimeter, equal to 0·00004 of a unit of heat. The proposition

$$9 : 34{,}462 :: x \cdot 0{\cdot}00004$$

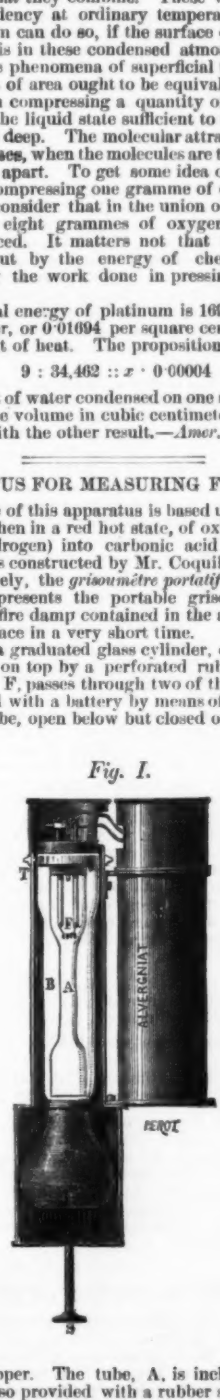
gives the weight of water condensed on one square centimeter of surface, or the volume in cubic centimeters as 0·00000001, which agrees with the other result.—*Amer. Jour. of Science.*

APPARATUS FOR MEASURING FIRE DAMP.

THE principle of this apparatus is based upon the property of palladium, when in a red hot state, of oxidizing fire-damp (carbureted hydrogen) into carbonic acid gas and water. The apparatus is constructed by Mr. Coquillon in two different shapes, namely, the *grisoumètre portatif* and *grisoumètre fixe*. Fig. 1 represents the portable grisometer. With it the quantity of fire damp contained in the air can be determined at any place in a very short time.

A represents a graduated glass cylinder, open at the bottom, but closed on top by a perforated rubber stopper. A palladium wire, F, passes through two of these perforations, and is connected with a battery by means of binding screws. A small glass tube, open below but closed on top, also passes

Fig. I.



through the stopper. The tube, A, is inclosed in a larger glass tube, B, also provided with a rubber stopper, through which another small tube like the one just described passes. A vessel, M, the bottom of which is composed of some membrane, is attached to the lower end of B. All these parts are incased in a sheet metal box or cylinder provided with two vertical slots for the purpose of enabling a person to read the scales. Before operating with the apparatus it is entirely filled with water. By opening the two small glass tubes and pressing the membrane upwards by the screw, S, a certain quantity of the gas or air to be examined can be admitted into the cylinders, A and B. The two small glass tubes are then closed, and the palladium is heated until it is red hot by means of the battery. As soon as the carbureted hydrogen is oxidized the levels in the two cylinders are made equal, the scales will indicate their position, and from the diminution of the water the quantity of carbureted hydrogen can be determined.

The fixed grisometer (Fig. 2) is adapted for measuring larger quantities of air. A is the graduated tube, B the palladium wire, C is a tube containing the gas or air, and F a

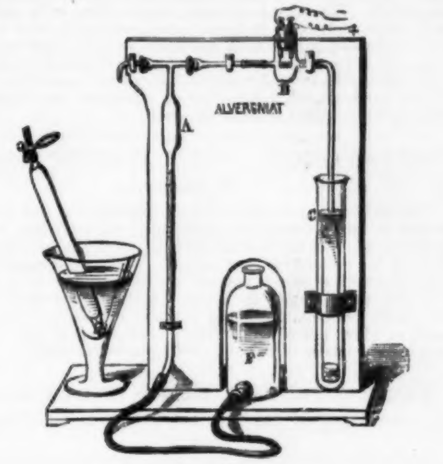


Fig. II.

vessel containing water. If the quantity of carbureted hydrogen is over 9 per cent., it will be necessary to mix the gas with air, as there always must be a surplus of oxygen. If a closed tube, D (Fig. 3), containing lye, be added to the apparatus, the same can be used for measuring any carbureted

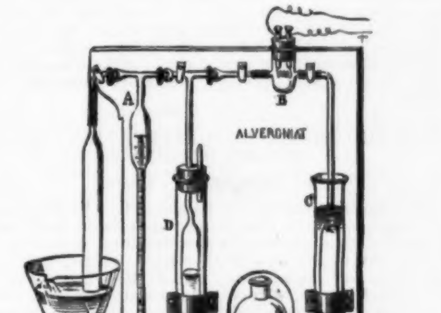


Fig. III.

gas, and is then known as the carborometer. For complicated gases it will be necessary to insert several tubes into D.—*Chemiker Zeitung.*

ALIZARIN CARMINE.

A NEW coloring material is manufactured under this name by the Austrian Alizarin Manufacturing Company. With tin as a mordant, it dyes wool orange; with alum, red. It is said to surpass all previous dyes of similar tints in beauty, brilliancy, durability, and variety of shading with different mordants, and resistance to change under exposure to light, air, perspiration, and washing.—*Fortschr. der Zeit.*

EXTRACTION OF GREEN COLORING MATTER FROM COFFEE.

M. ZECH announces his discovery of a simple method by which an innocuous green pigment, suitable for coloring sweetmeats, preserved vegetables, etc., may be extracted from coffee. The berries are first soaked, and the oil then removed from them by the action of alcoholic ether. They are then dried, and shaken up with white of egg, and the species of marmalade thus obtained exposed to the atmosphere for a few days. The presence of the albumen of the white of egg determines the appearance of a magnificent emerald green. Another equally easy way of obtaining the coloring matter is to simply steep the berries in water, after they have been bruised, and deprived of their oil by washing with alcohol.

CONVEYING ACIDS.

M. KUHLMANN, in place of carboys, employs floating reservoirs in the form of an ordinary boat, fitted with air chambers to give them sufficient buoyancy. For sulphuric acid of 60° B. and upward these are constructed of sheet iron, and have been in successful use for some years on the canals of the north. For hydrochloric acid he uses cylinders of hardened India-rubber, kept in their form by an external framework of wood. A modification of the structure serves for transport by rail.

M. GAIFFE'S GALVANIC DEPOSITS OF COBALT.

THE metal is deposited from a solution of the double sulphate of cobalt and ammonia, and is superior to nickel at once in hardness, tenacity, and in beauty of color. It is much less oxidizable than iron, but is very easily dissolved by acids.

BLEACHING OSTRICH FEATHERS.

ACCORDING to the *Moniteur des Produits Chimiques*, feathers are bleached in a bath of 10 grms. barium peroxide to 1 liter water, heated to 30°. In this they remain for forty-eight hours, and are then washed, treated with weak hydrochloric acid, and dried.

A MORDANT FROM LEES OF WINE.

FRESH green lees, with the addition of two-fifths sodium tartrate, are evaporated down to one-sixth the original volume. 15 grms. of Cologne glue and 10 grms. tannic acid are added. The mass is pressed, rubbed over with alcohol and tannic acid, dried in the air, and powdered. For use it is to be further mixed with one-fifth per cent. sodium tartrate. It is recommended for dyeing full shades in wool and silk, and is said to render the aniline colors permanent. In dyeing woolen cloth a decoction of saponaria root is added both to the mordant and the dye bath.

THE TAR COLORS AND THE ELECTRIC LIGHT.

By DR. GREIFF.

THE author contends that, even supposing the gas manufacture should ultimately be abandoned, the tar colors could be prepared from the residues left on rectifying the petroleum of the regions on the Caspian. These are estimated at 120 million kilos yearly, and are ten times richer in benzol and five times richer in anthracite than is coal tar. The American petroleum has not yet been examined from this point of view, but it will probably also prove to be a rich source of aromatic compounds.—*Chemische Industrie.*

WATER IN THE PREPARATION OF RAW SILK.

[Communicated by the Instituto Technico Superiore of Milan.]

IN silk are distinguished the soluble constituents, varnish, or gum, and coloring matters, and, on the other hand, the insoluble fiber. The soluble constituents give raw silk its brightness, color, and strength, and should therefore be preserved as far as possible. For the purpose of unwinding the cocoons the natural gum should be softened, but not dissolved. According to Franceson, silk, if deprived of all its soluble constituents, loses at the same time its strength and elasticity. The authors find that though the loss of strength is proportional to the loss of soluble matter, the elasticity is but slightly diminished. In order to minimize the loss sustained in softening the cocoons hard waters are used, and soft waters are artificially modified by the addition of sulphate of lime and carbonate of soda. Silks which are to be dyed bright colors, however, should be spun out of soft water.

THE PHOTOGRAPHIC OBSERVATION OF THE OXYGEN SPECTRUM.

By HERMANN W. VOGEL.

THE spectrum showed the lines described by Paalzow, O between b and E, O close by F, and O between F and G. A band of great intensity, which the author names O , lies near h. It is sharply defined toward the red end of the spectrum, but shades away toward the violet extremity. A double band, Os, near G, has the same character. In the spectrum of hydrogen the three already-known hydrogen lines in the blue and violent were seen very distinctly, and also the red line, Hα, coincident with C of the sun. The fourth hydrogen line, coinciding with "h" of the sun, was observed with the naked eye by Paalzow and the author, on the application of the simple induction current, in opposition to the assertion of Lockyer that it is only visible at very high temperatures. Upon this assertion he founds in part his supposition of the decomposition of hydrogen at elevated temperatures.

INFLUENCE OF BORACIC ACID UPON ACETIC FERMENTATION.

By. PROF. A. HERZIN.

IF an aqueous solution of boracic acid is added to pressed grapes in the proportion of one-twentieth by volume, fermentation is neither arrested nor retarded. The wine produced seems rather clearer than usual, but does not in any way betray the presence of boracic acid. But if the wine is placed in conditions most favorable for conversion into vinegar this change is absolutely frustrated. The author holds that the acetic micoderma lives at the expense of vinegar already generated and not of alcohol, and is a consequence rather than a cause of the chemical changes which are prevented by a trace of boracic acid.

ACCORDING to the *Technologiste*, common rosin prevents the formation of acetic acid in fermented liquids without having any disturbing effect on the process of alcoholic fermentation. The peculiar effect of the hop may be due, it is suggested, to its resinous matter rather than to its oils. Resin is added to sweet wines in Greece.

ALUMINUM.

By CLEMENS WINKLER.

THE history of the development of the art of working in aluminum is a very short one—so short that the present generation, with which it is contemporary, is in danger of overlooking it altogether. The three international exhibitions which have been held in Paris since aluminum first began to be won on a commercial scale form so many memorials of its career, giving, as they did, at almost equal intervals, evidence of the progress made in its applications. In 1855, we meet, for the first time, in the Palais de l'Industrie, with a large bar of the wonderful metal docketed with the extravagant name of "silver from clay." In 1867 we meet with it again, worked up, and get a view of the manifold difficulties which have been overcome in its production on a large scale, its purification, its moulding. We find it present in the form of castings, sheets, wire, foil, or worked-up goods, polished, engraved, soldered, and view for the first time, and in varied forms, its most important alloy—aluminum bronze. After the lapse of almost another dozen years, the Paris Exhibition offered us, in 1878, the view of the maturity of the aluminum trade. We have passed out of the epoch in which aluminum was worked up in single specimens, showing the future capabilities of the metal, and see it accepted as a current manufacture, having a regular supply and demand, and being in some regards commercially complete.

The despair that has been indulged in as to the future of aluminum is thus seen to have been premature. The manufacture of aluminum and of aluminum goods has certainly not taken the extension at first hoped for on its behalf. The lowest limit of the cost of manufacture was soon reached, and aluminum remains a product won only by an expensive series of operations from one of the cheapest and most common of raw materials. On the other hand, it is, for a variety of purposes, steadily displacing other cheap metals, over which it is seen to have incontestable advantages. Its color and luster are pleasing, while its peculiar lightness fits it in an unrivaled manner for many purposes, both of science and luxury. This low gravity has to be taken into account when we compare the price of aluminum with that of other metals, since it has, weight for weight, three times the available substance of iron, copper, brass, and nickel, and four times that of silver.

To France is due the merit of having been the first country to carry out Wöhler's process for the production of aluminum on a practical scale, and to have created the aluminum manufacture. France still seems to be the only country in which the manufacture is able to prosper. The English manufactory established at Washington, near Newcastle-on-Tyne, by Bell & Co., did not answer, and has been shut up now for about five years. The German manufactory set up at Berlin by Wirtz & Co. cannot be said to have really lived at all, it drooped before it was well started. In France, the great chemical manufactory of H. Merle & Co., in Salindres, near Alais (Paris offices, 15, rue de Quincampoix), carries on the extraction of aluminum, and the Société anonyme de l'aluminum in Nanterre (Seine), works up the metal into the various forms demanded by commerce. Both firms were represented at the Exhibition. Merle & Co. had a splendid display of bars of the metal, while the Société anonyme exhibited samples of worked up goods of all kinds, in testimony of the progress made in its adaptation to various purposes. A byproof was exhibited by them of the high quality of the metal now attained to. But for this it would not have been possible to exhibit reels of brilliant wire, fine as human hair, or beautiful sheets of extraordinary tenuity. There were also exhibited stampings in aluminum—large medallions and pieces weighing exactly 1 gramme, to show the lightness, compared with the bulk of the metal. In one pan of a balance there were shown five large keys made of aluminum, which were counterpoised by a single iron key in the other pan. The peculiar bluish-white luster of the metal also compared to advantage with the hue of tin and zinc.

The same favorable impression is renewed when the visitor makes his way to the Maison de l'Aluminum (Boulevard Poissonnière), where are exposed for sale the articles manufactured by the Société anonyme. Here can be purchased articles the most simple or the most costly, from a thimble or penholder to a complete dinner service, in pure aluminum or aluminum bronze. The very beautiful objects made with great skill in aluminum bronze, and sold at very cheap rates, are more popular than those made in pure aluminum, which is relatively dearer. Buyers are noticed to take up and admire aluminum goods, and to lay them down again the moment the price is mentioned. Small articles only are found to sell, among them I especially notice some pretty specimens of fine wire work.

It is getting to be a common thing in Paris to make the framing for opera glasses and telescopes of aluminum. The effects got are often very beautiful. Houses which cultivate this branch of manufacture with success are Clermont (rue du Temple), Lemair (rue Oberkampff, Fischer (rue de la Paix). Still, successful as is this application of aluminum, it is, perhaps, not the happiest possible. The most rational use indicated for aluminum, by reason of its low specific gravity, is the making of beams for balances. Aluminum bronze beams have been made for several years past; but, so far as lightness of metal is concerned, they have scarcely any advantage over brass. Sartorius, of Göttingen, was the first who made light and unalterable beams of an alloy of aluminum with 4 per cent. of silver. He has had but few imitators. The Exhibition contained but one single balance the beam of which was made of pure aluminum. The balance was exhibited by M. Collot (Boulevard Montrouge); it carried 100 grammes, turning at 0·1 milligramme; its price was set at £80. There are several reasons for the small amount of favor shown to aluminum by mathematical instrument makers and others. First of all there is the price, then the methods of working it are not everywhere known; and further, no one knows how to cast it. Molten aluminum attacks the common earthen crucible, reduces silicon from it, and becomes gray and brittle. This inconvenience is overcome by the use of lime crucibles, or by lining the earthy crucible with carbon or strongly burnt cryolith clay. If any one would take up the casting of aluminum and bring it into vogue as a current industrial operation, there is no doubt that the metal would be more freely used in the finer branches of practical mechanics.

The prices per kilogramme quoted in the last list issued by the Société anonyme are as follows:

Aluminum—	
Bars	130 fr.
Sheets, 0·5 to 0·1 millimeter	135 fr. to 160 fr.
Wire, 2·0 to 0·3 millimeter	170 fr. to 200 fr.
Aluminum bronze (10 per cent. alloy)—	
Bars	18 fr.
Sheets, 2·0 to 0·5 millimeter	24 fr. to 30 fr.
Wire, 7·0 to 1·C millimeter	28 fr. to 39 fr.

After aluminum bronze, this well-known beautiful alloy, which does not change color at a melting heat and gives golden yellow castings, the alloys of aluminum with silver deserve attention. They seem to possess admirable properties, are exceedingly easy to work, and are practically unchangeable. For these reasons it would seem desirable that attention should be given to their preparation and utilization.—*Industrie Blätter.*

ELECTRO-DEPOSITION OF NICKEL.

MANY of the nickel manufactures are now considered to surpass silver in appearance, whilst the price is very much lower. It is now likely to become a still greater favorite, as Mr. Edward Weston, of Newark, New Jersey, has discovered a method of electro-deposition of nickel and for producing malleable ductile nickel suitable for manufacturing into solid nickel articles.

Mr. Weston's invention consists chiefly in the production and use of a constant nickel solution—that is, a perfect nickel solution, which, although continuously used as an electrolyte, permanently preserves its composition. The most important feature is the discovery that the deposition upon the cathode of the subsalts of nickel is entirely prevented when the solution employed is made to contain a solution of boracic acid or of compounds of boracic acid; and the further discovery that borate of nickel, although insoluble in water, is very soluble in many of the solutions of salts of nickel, and that solutions of borate of nickel with salts of nickel afford a perfectly reguline deposit, and are especially efficient for electroplating and electrotyping purposes. The deposit is, moreover, of a beautiful white color, and is easy to polish, whilst it is very flexible and tough, and adheres firmly to the surface upon which it is deposited. In compounding the said constant solution the proportions of the ingredients are not arbitrary, but may be varied without changing the distinctive characteristic of the solution, that of constancy.

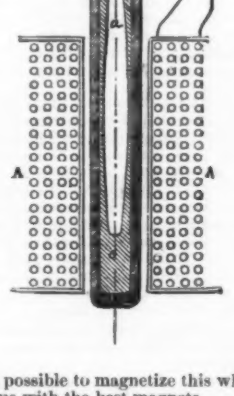
An excellent solution may be made by using 5 parts of chloride of nickel and 2 parts of boracic acid. Another good solution may be made by using 3 parts of sulphate of nickel and 1 part of boracic acid. Either of these solutions may be slightly improved by the addition of caustic potash, soda, or lime, until the precipitates formed cease to be dissolved. It will be found that the metal obtained by electro-deposition from either of these solutions is remarkably tough, coherent, flexible, and smooth, malleable, and ductile.

The rapidity, ease, and certainty with which the electro-deposition of the nickel is effected when the boracic acid is added is marvelous, and Mr. Weston is enabled to produce by this means considerable masses of nickel by electrolysis. It has not heretofore been practicable to make nickel electrotypes because of the nicety of adjustment necessary both in maintaining the composition of the solution and in regulating the strength of the current employed. Constant care and watchfulness have had to be exercised to preserve the composition of the solution by the addition of ingredients rendered necessary by the changes here referred to, in order to prevent the separation of nickel from the mould. By reason of the extreme slowness of the depositing operation, nickel electrotypes, even when by the exercise of great skill and watchfulness they have been made, have been too costly for practical use. Furthermore, the deposit has always been brittle and could not be annealed without warping out of shape. By this invention all of these difficulties are avoided, and the art of producing electrotypes of nickel, and of depositing considerable masses of nickel upon black-leaded or metallized surfaces, is made perfectly practicable. The power of boracic acid or its compounds to prevent the deposition of sub-salts of nickel on the cathode is so great that solutions which have not been heretofore capable of practical use, because of the sub-salts of nickel deposited from them, can be made practically effective solutions by the addition of boracic acid, even in minute quantities. For example, the solution of the double salts of nickel and potassium, the solution of the double sulphate of nickel and magnesium, and other solutions of similar composition which heretofore could not be used, are converted into excellent plating solutions by the addition of a small quantity of boracic acid, either in its free or combined state.

It will, of course, be understood that although Mr. Weston prefers to avoid the use of ammonium salts in the composition of his solutions, he does not in all cases reject the use of such salts; but he finds that solutions of double salts of nickel and ammonia can be materially improved by the addition of boracic acid or its combinations. By this invention electrotypes in nickel are as easily made as electrotypes in copper. His deposit spreads rapidly and evenly over the plumbago or other conducting surface of the mould, and the metal obtained from his solutions is ductile and malleable, and when annealed can be drawn into wire or rolled and manufactured into various articles which are now usually made of brass or copper, results which have never heretofore been obtained. The metal deposited by these solutions adheres so firmly that it becomes possible to stamp, spin, or shape into a variety of forms for various uses sheets of metal coated with nickel. Even a small percentage of boracic acid may be applied with especially good results to solutions of chloride of nickel with chloride of magnesium, chloride of nickel with chloride of sodium, chloride of nickel with chloride of calcium, and to all of the solutions of either the chlorides or sulphates of nickel with the chlorides or sulphates of all the alkalies or alkaline earths; and furthermore, tartrates and other alkaline salts can be used, the percentage of boracic acid being in all cases varied at will.

MAGNETIZATION OF MOLTEN IRON.

A BAR of steel, after having been submitted to one of the numerous processes capable of inducing magnetism therein, always remains magnetized, and we thus obtain a permanent magnet, which, however, gradually loses power. The more highly steel has been tempered, the more difficult it becomes to magnetize it; but as an offset to this, the more highly tempered the steel, the less liable it is to lose the magnetism by age. With these facts, which are known to every one, as a basis, M. Chernoff was led to form the following hypothesis: White cast iron on cooling assumes a degree of hardness which it is almost impossible to make steel reach.



Now, if it were possible to magnetize this white cast iron, it would furnish us with the best magnets.

To confirm this view, M. Chernoff made the following experiments.

He took a funnel shaped mould, B, in which he poured refined molten white iron. The mould, B, was surrounded by a coil, A, through which was passed an electric current. Things being thus arranged, the metal remained submitted to the inductive effect of the electric current during the whole time that it was cooling. The operation ended, Mr. Chernoff took from the mould a bar of magnetized white cast iron.

The following phenomena took place during the course of

the experiment. The molten iron, poured into the mould, B, placed in the center of the induction coil, A, traversed by the electric current, remained in a state of agitation up to the moment of its solidification by cooling. As the mould had been dried with the greatest care, this effect could not be attributed to the presence of moisture. The figure annexed, borrowed from *La Revue Industrielle*, represents a section of the apparatus employed, one third natural size.

It will be seen that the casting, *c c*, was hollow; when taken from the mould it broke very easily. The least thickness of metal was found to exist in the portion nearest the center of the bobbin; at this point the casting was almost as thin as a sheet of paper.

It was evident then to M. Chernoff that the molten metal had undergone the influence of the electric current which was circulating around its mass, and the molecules of the liquid metal, free to move about, had obeyed the laws of polar attraction. The liquid mass, submitted to the action of gravity on the one hand, and to magnetic action on the other, had naturally been agitated, as was observed, during its cooling.

The greatest magnetic intensity was found to exist at the point *a*; but its further distribution was not studied, as the experimenter's attention was more particularly directed to the structure of the metal.

M. Chernoff proposes, however, to repeat his curious experiment, and to study magnetized bars of white cast iron more closely.

REMEDY FOR BLOW HOLES IN CAST METAL.

IT is well known that in the case of many metals great difficulties are met with in obtaining a fibrous structure on their being melted and cast, but such fibrous structure must especially be obtained in those cases where it is intended to subject the object cast to further mechanical treatment. For this reason it has hitherto been quite impossible to produce by the process of casting nickel or cobalt objects which could be subjected to a subsequent treatment of pressure, rolling, hammering, etc. They have always shown a crystalline fracture with blow holes, and have broken on being subjected to mechanical treatment. The electrolytic process, as also the process of cementation (reduction from oxide), have, however, shown that nickel metal in itself may be perfectly well adapted to sustain any mechanical treatment.

Considering the very much greater commercial value which the process of producing objects by casting presents as compared with the electrolytic process and cementation, it becomes of great importance to find a means of producing objects from nickel by casting, having a fibrous structure free from blow holes. During fifteen years Mr. Theodore Fleitmann has made experiments in this direction, and has finally found the solution of the problem to consist in the addition of magnesium to the melted nickel metal. The metal thus produced shows a fibrous structure perfectly free from blow holes, and as experiments have proved, allowing of every kind of mechanical treatment. Mr. Fleitmann does not deem it necessary now to enter into an examination of the chemical action which here takes place, as to whether the magnesium by its presence causes the result, or as to whether it destroys injurious admixtures (absorbed gases, etc.) Further experiments with other metals, such as iron, steel, copper, and their alloys with nickel, tin, and zinc, have led to the same result. A small addition of magnesium would also give to these metals considerably greater elasticity and ductility than that which they possess without the addition of magnesium.

The carrying out of the process is a very simple operation, and substantially consists in introducing the requisite quantity of magnesium through a small opening in the cover of the crucible containing the molten metal after it has been cleared of all dross, and the mixture of the same together by agitation of the vessel. It is somewhat difficult to know the proportionately proper temperature for producing the action; before the introduction of the magnesium the metal to be treated must be heated considerably above its melting point, as otherwise it may happen that after the addition of the magnesium the whole mass will congeal or be too thick for pouring.

All that has here been said with regard to nickel applies equally to cobalt, which is an analogous metal. To make the matter clear Mr. Fleitmann's invention may be summed up as consisting in the use of an addition of magnesium to other metals, especially to nickel, cobalt, iron, steel, copper, and to the alloys of this metal with nickel, tin, and zinc, for the purpose of producing in the casting of these metals and metal alloys objects of greater ductility, of more fibrous structure, and without blow holes.

NORWEGIUM—A NEW METAL.

FROM the *Chemical News* we learn that a newly-discovered metal, Norwegium, has been detected and isolated by Dr. Tellef Dahll in a sample of copper-nickel from Krageröe in Skjærgaarden. The color of the pure metal is white, with a slight brownish cast. When polished it has a perfectly metallic luster, but after a time it becomes covered with a thin film of oxide. It can be flattened out in an agate mortar, and in hardness it resembles copper. The melting-point is 350° C., and the specific gravity 9·441. Its equivalent appears to be 145·9. Only one oxide, NgO, has been obtained. With sulphureted hydrogen it gives a brown sulphide, even in strongly acid hydrochloric solutions, which redissolves in ammonium sulphide. With a slight addition of potassium ferrocyanide it gives a brown, but with larger proportions a green precipitate. The sulphuric solution is turned brown on the addition of zinc, and the metal is deposited in a pulverulent state. The solutions of this metal are blue, but become greenish on dilution.

THE AFFINITY OF LANGUAGES.

RUDOLPH FALB, a German professor, recently arrived in San Francisco, after spending two years in South America, and now on his way back to his native country, authorizes the *Alta* of that city to announce that he has made discoveries of great interest to ethnology and philology. While in Bolivia he studied the Aymara tongue, which was in use before the Spanish conquest, and is older than the Quichua, which was spoken by the Incas and their subjects in Peru. This Aymara language, still spoken by 8,000,000 people of the aboriginal blood, bears an unmistakable and near affinity to the Semitic tongues in which the radical form of every verb has three consonants. The Arabic and the Hebrew are the leading languages in this class, and the relationship of the Aymara to them is strong and unquestionable throughout.

If this discovery should prove to be well founded, it will have an immense influence on the opinions of the learned world. Some of the most interesting researches of the present century have been made in the same direction. The discoveries that the Sanscrit, Hindostanee, Persian, Afghan, Armenian, Caucasian, Slavonic, Teutonic, Celtic, Latin, and Greek tongues all belong to the inflected class of languages; that many of their principal words, such as father, mother, brother, daughter, horse, ox, fire, sun, sky, light, dark, come, go, see, hear, eye, ear, hand, mouth, and so on, have similar sounds in these different tongues; and that ideas of later origin, connected with a high degree of civilization, such as pen, ink, paper, gun, pistol, and so on, are different—these discoveries have proved that the Aryan nations, as they are called, all sprang from a common stock in central Asia, whence most of them migrated to Europe. By examining the Sanscrit, the oldest of these tongues, and comparing it with the others, we can tell much of the intellectual, industrial, political, and social condition of the early progenitors of these people, which races first left the common stock, and how much progress was made before the separation. The word for daughter—differing little from the English and German words—in the Sanscrit means milkmaid, and, therefore, while the ancestors of the Germans were still living with the ancestors of the Hindoos, in Asia, they had cows. By the same method of reasoning, we know that they had plows; that they had religious ideas and forms of worship; that they had political rulers, military training, and so on. We know, further, that the people who speak the agglutinative languages, like Magyars, Turks, and Tartars, and the monosyllabic languages, like the Chinese, are of a different blood. Ethnologically, the Semitic races—the Phœnicians, Hebrews, and Arabs—are clearly distinct from the agglutinative stock, but whether they are to be classed as belonging to the same blood with the Aryans, is a question about which philologists and ethnologists are not agreed.

If, now, the Aymara is a Semitic tongue, the learned world will have a hard task to determine whether Asia or South America was its original seat, and how the transfer was made without leaving any large mass of its active and imperious blood on the long road. Was the high plateau of South America the cradle of the Semitic, as that of Asia was the original home of the Aryan kindred? If we understand Professor Falb correctly, he would answer that question in the affirmative; and, if he establishes his point, we do not hesitate to say that he will take a place among the greatest discoverers and stimulators of thought and research in our age of unparalleled and unapproached intellectual activity. There may be no money in it, but there is an immense educating and refining influence in tracing back the history of man through the different steps of his natural progress from the lower condition of savagism in the Stone Age, before he had yet learned to make metallic tools, to his present enlightenment.

Four miles south of Lake Titicaca, 13,000 feet above the sea, in Bolivia, is the ruin of an Aymara temple, with a large stone covered with carved hieroglyphs or figures. These hieroglyphs Professor Falb claims to have interpreted, and he finds in them the proof that this temple was erected as a memorial of a great flood. One of its principal figures contains Masonic signs, which mean the light, the thought, the word, the beginning; and the signification and history of these signs, after having been lost for thousands of years, are now again to be brought within the general comprehension. Figures, used as religious symbols in very remote days, were preserved long after some of their meanings were forgotten. The philological world will look with interest for Professor Falb's revelations.

THE SPIRITUAL IN MAN.

IT is one of the weaknesses of human nature that the intellect can seldom take cognizance, or even retain a firm and clear mental grasp, of more than a single phase of any subject at once. And by long dwelling on a particular line or aspect of observations, the mind becomes so imbued with its special characteristics that it ceases to be able to adapt the range and mode of thought to any other. This twofold imperfection—the lack of power to take a broad view, including the reverse as well as the obverse of a subject, coupled with a tendency to mannerism, amounting almost to finality of method—constitutes a serious hinderance to the pursuit and conception of truth. For example, seeing only the physio-chemical and crudely "vital" side of nature, men engrossed in the investigations of medical science too often not only ignore, but by an exclusive process of reasoning deny, the existence of anything outside the field of their philosophic vision. It is nothing to the rationalist that the idealist is not less confident in the sufficiency of his philosophy, than he is in the compass of his own. Nor is the rigid realist and evolutionary materialist prepared to concede as much to the thinkers of other schools, as COMTE conceded when he recognized that the intellectual needs of human nature craved a belief outside positivism.

There is an affectation of scientific principle in the determination to admit nothing which cannot be proved, to reject every form of evidence except the specifically demonstrative, which gratifies the vanity of the philosopher, and so cheats his senses that he seems to stand alone on a firm footing, while all around him glide. What if fixity, even the sort of permanence which appears to be an attribute of principle, is incompatible with science? Supposing it should hereafter be found—as some think the past has shown—that truth is progressive, that the horizon stretches away as we approach it, that the "impossible," and things that "cannot exist" of yesterday, become the ascertained facts, the postulates of to-day? What if the very method of our inquiry be at fault, and the powers we bring to bear upon the task of investigation are only part of the means at our disposal, if we persist in looking at the objects around us with one eye, when we have been provided with two? Supposing man is not wholly physical or material, and it is because he refuses to use the spiritual powers at his disposal he fails to perceive what lies beyond the reach of his senses.

Men of highly cultivated intellects have, in times past, believed in the existence of a soul, and there have been minds, not fatally tainted with disease, which have cherished faith by the side of reason, without finding the two forms of energy mutually destructive. Some, who have done good work in science, have even gone so far as to deem the proofs of a spiritual element in man's nature as many and conclusive as those which attest the existence of his organism; the belief in a God as permissible as the belief in a protoplast, and the recognition of a spiritual entity as reasonable as the cognizance of matter.

If proof were needed that this is the true scientific position in respect to these subjects, it would be found in the fact that a strong and real difference of opinion exists as to their nature and claims on our attention. The strife between rival creeds and faiths may not convince the philosopher that any one of the number is the true faith to the exclusion of others; but it does show that faith is a normal form of mental energy.

The larger part of mankind would not exhibit faith, religion would not be found to become increasingly spiritual with the growth of intellect in the development of races and peoples, and man as an animal would not be gifted with faculties, a mind, and aspirations, connecting his hopes and fears, his motives and impulses, with another life and another world, if there were no other life or state of existence to call forth these qualities. It is a fundamental law of realism and evolutionary materialism that the developmental impulse springs from the surroundings. If these require the development of a particular organ or faculty, it grows in obedience to the need of circumstances, which acts as a stimulus. This law applies to the development of faith in man, and to the growth of his spiritual nature, not less than to the parts of his organism. If there were no object to inspire and attract faith, that form of mental energy would not exist. If there were no future, there would be no hope therein. We will go farther still, and affirm that the very antagonism of cultivated minds to the doctrine of spiritual entities and forces is a strong corroborative proof of its verity. The mind only attacks with vigor what it instinctively feels to be a strong enemy.

When a thinker of known ability persistently and laboriously strives to demolish the belief in a personal God, in his inner consciousness he feels the force of the evidence that such a Being exists. It is this stimulus of conviction—a conviction he is ever seeking to efface—that incites him to efforts wholly disproportioned to the needs of an onslaught on a belief known and felt to be utterly groundless. When a man describes prayer as "imbecility of the will," he himself prays. When he incessantly quotes Scripture to pour ridicule on the faith of the majority, this is, in itself, evidence that he has not the power to shake off its influence or to uproot the faith he derides.

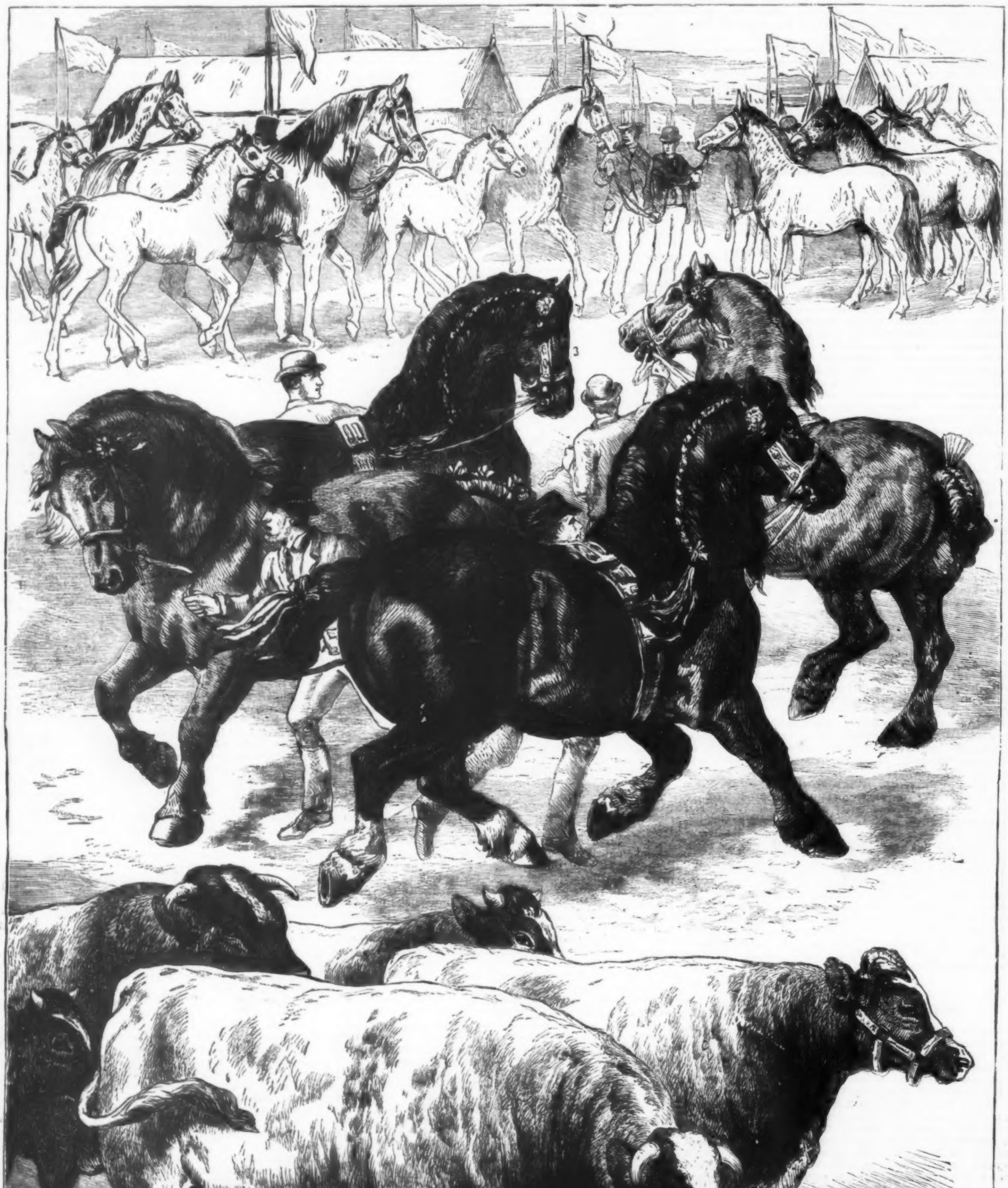
The time has come to speak out boldly on this subject, and we are persuaded the good sense and self-respect of the profession will approve the protest against that spirit of restless antagonism to the claims of religion, which has unhappily obtained fuller expression in a small section of our ranks during the last few years, and which, if not repudiated, must be expected to increase. The position we assume in reference to this matter is one which may be easily defined. We are not the apologists of any special creed, but we say faith is a rational and natural form of mental activity. The religious instinct is an essential part of man's nature. There is a distinctly spiritual side to his character. The existence of hopes, fears, and aspirations—call them *susceptibilities* only, if any one prefers the term—is in itself evidence that there are spiritual surroundings and subjects of thought which call these forms of energy into existence. It is scientifically possible that not one of the forms of belief extant may be true to fact, and yet the existence of faith proves conclusively that there is subject *for faith*.

It is not philosophic to affirm that nothing exists, or can exist, beyond the scope of our observation. It is not rational to believe that man has been imbued, as we find him imbued, with a longing for personal immortality, without the existence of a future state which has called forth, and will hereafter justify, his aspirations. Nor is it scientific in a practical sense to consider the intellectual development of human nature complete without the manifestation of a religious element in the character. He is not of sound mind who has no cognizance of the spiritual part of his own nature. We make this assertion without hesitation and in full view of the puerile remark it may provoke. We deny that faith is a pure figment of the imagination, and that the religious emotions are simply visceral in their origin and nature. We take our stand on the broad basis of *fact*, and find faith, religion, and a spiritual phase of the human intellect falling within the compass of the mind. Moreover, we find the moral character largely influenced by the motives and impulses that spring from without. In the face of these evidences, we cannot but recognize the value and importance of earnest views of life and the future. It is, therefore, with sincere satisfaction we observe the effect which has been produced by the posthumous confession of a simple Christian faith promulgated in these columns at the request of the late Tilbury Fox. We venture to hope it is only the formal expression of belief which has constituted the notable feature of this case. The faith exceptionally expressed is, we are glad to believe, widely cherished. There would seem to have been a feeling prevalent in the medical profession of late years that men of our cloth should avoid the avowal of their personal sentiments on religious subjects. We agree that the physician should not usurp the functions of the minister of religion, but he is forbidden by the spirit of manliness to take refuge in the opposite extreme of moral cowardice with a pretense of indifference. Men engaged in the ministry of medicine in the chamber of sickness and by the bed of the dying must needs have solemn experiences, and there is doubtless a tendency to arm the sensitive nature and conscience against the pathetic appeal of scenes in which we are professionally engaged. Against this leaning towards an assumed and artificial state of apathy it is necessary to guard. The dying confession of our friend and colleague may help some to take up a better and healthier position in regard to subjects of the highest and most enduring concern. The use made of the incident to which we have alluded by clergymen and ministers of every denomination is to be commended, albeit some of the remarks offered have been marred by sneers at the medical profession, which we feel to be undeserved, and therefore discreditable. In another column we instance the observations of the Rev. T. S. Coles, of Chobham, who has judiciously noticed the subject. It remains to hope that others will find in the few telling sentences left on record by Dr. Fox an occasion for equally wise and generous comment. For ourselves, and the profession as a body, we claim to be considered as having neither part nor interest in the speculations of men who mistake a spirit of sententious skepticism for scientific zeal and acumen; and who, by the restless energy of their enterprise against religion, and their unwearied anxiety to deprive man of his hope, beyond the present, are unwilling witnesses to the truth they assail—the unconscious contributors of a living testimony to the faith they despise. Such short-sighted laborers in the field of science, blind to all that lies around and outside the circle of a narrow vision, may be good and true workers within the limits of their enterprise, but they err egregiously in closing their eyes to everything beyond.—*London Lancet.*

PRIZE ANIMALS.

IN our SUPPLEMENT for August 16, No. 189, we presented several engravings of the recent International Exhibition of the Royal Agricultural Society, Kilburn, Eng., with interesting particulars of the grand display. We now give illustrations of the prize animals, for which we are indebted to the *Illustrated London News:*

1. Hackney mares, with foals and mules, being led out for judgment.
2. The Earl of Ellesmere's Young Prince of the Isle, winner of the first prize in the class of three-year-old agricultural horses.
3. The Earl of Ellesmere's Samson III., winner of the second prize in the same class.
4. Mr. Richard Garrett's Cupbearer III., winner of the first prize in the class for Suffolk horses, four years old and upwards.
5. Mr. David Buchanan's Druid, winner of the Champion Cup and the first prize in the class for Clydesdale horses, four years old and upwards.
6. The Marquis of Exeter's Sea Gull, with Telemachus IX., another of her sons, and two daughters, the first prize shorthorn family.



ROYAL AGRICULTURAL SOCIETY'S EXHIBITION.—PRIZE ANIMALS.

CULTURE OF THE RASPBERRY.

Compiled by ABEL F. STEVENS from Fuller's "Small Fruit Culturist," with Description of Varieties best suited to New England Climate.

HISTORY.

THIS, the most luscious of all the small fruits, we find has been cultivated from the earliest times, for we learn in ancient history that Pliny the Elder, who wrote about A.D. 45, mentions the raspberry as one of the wild brambles which the Greeks called Idæa. Palladius, a Roman agricultural writer in the fourth century, mentioned the raspberry as one of the cultivated fruits of his time, but like most of the other small fruits, very little improvement was made until within the past century; for all depended upon the wild plants.

SPECIES.

Of the cultivated kinds of to-day we have *three species*, viz., *Rubus strigosus*, the native red varieties; *R. occidentalis*, the black-cap varieties; and *R. Idæus*, the European varieties, from which nearly all of our best kinds have been produced. The cultivation of the above varieties we will consider under propagation, soil, culture, and varieties. The raspberry is propagated by seed, root cuttings, layers, and suckers. The method by *seeds* is seldom used except to produce new varieties, but by root cuttings and suckers for all of the red varieties, and by layering the tips of the canes of the black cap varieties. Root cuttings are made by taking the roots up in the fall and cutting them into two or three inch pieces; place these in boxes of moist sand, secure from freezing. In this state the pieces "callous" or heal over the inner bark (a cellular growth of cambium or healing of the inner bark), which always precedes the formation of young roots. When the soil is dry and warm, with a little fine warm manure in the furrows, these cuttings may be planted out some three or four inches apart. Some of the best varieties are slow to form root buds, and require a little forcing, either in a propagating house or hot bed; if thus forced, see that they have sufficient moisture and ventilation after the formation of the leaf. When these plants have made from four to six inches growth, they should be transplanted in warm, moist weather. Root cuttings produce the very best plants. The black-cap varieties are propagated by layering the tips of the canes in early fall. This operation is simple and quickly done by lifting the soil with a hand trowel and inserting the tip of the young cane under, and in a few weeks a mass of fibrous roots will be formed, and will grow till the ground freezes, when the canes should be cut and these tips well covered for protection.

SOIL.

All of the Antwerp, or foreign varieties, require a deep, rich, moist soil, thoroughly enriched with a good compost of manure and muck, and plowed deep and fine. The black-cap varieties succeed better on a light, sandy loam, well fertilized, with a compost of lime and good muck, or wood ashes in the place of the lime, well incorporated. A thorough preparation of the soil before planting is very important, with good, clean, deep cultivation and a liberal top-dressing annually applied to the roots.

PLANTING.

After plowing and harrowing the ground, then mark the rows six feet wide, and set the plants four feet apart in the rows, making 1,815 plants to the acre. The black-caps should be set in rows seven feet wide, as they overhang, and four feet apart, making 1,555 plants to the acre. Select plants that have plenty of fibrous roots. Always cut the canes down even with the surface at the time of planting so as to produce a good strong root which will soon send up vigorous canes.

PRUNING.

The canes of the raspberry are biennial, that is, the canes growing the first year and bearing fruit the second; after which they die and new ones take their places. After the leaves fall, cut away the old canes, and in the growth of the young ones, when three feet high, cut back the tips, which will cause them to grow stout and thick, and send out side shoots which must be cut back also, thus making the plant self supporting. The cap varieties should not be more than three feet high before cutting back all of the rampant shoots and shortening the lateral branches. We have found from experience that a large, sharp sheath-knife is the very best article for this work, which can be rapidly done by a smart boy. All weak suckers and superfluous canes should be hoed out in the cultivation, as they weaken the fruiting canes.

WINTER PROTECTION.

Nearly all of our best varieties require protection to insure a full crop of fruit. The best and quickest method is to lay down the canes and cover with soil, after pruning out all of the old canes and thinning the young canes to four or five to a hill. One man should bend down the canes, and another should throw a shovelful of soil on them to hold in place. When all are thus secured, a plow is passed down on each side of the row, turning the soil upon them; do *not* cover the canes *too early* in the fall, but just before the ground freezes. All the varieties of *Rubus occidentalis* and *R. strigosus* are hardy and need no protection other than a good mulch of coarse manure placed around the roots in the fall.

SELECTION OF VARIETIES.

Of red varieties, we would recommend for market the following list:

Brandywine.—Canes hardy, vigorous, and productive; fruit large, quite firm, and a beautiful bright-red color; quality good; an excellent market variety.

Delaware.—Canes very hardy, productive, and vigorous; fruit very large, bright-red, firm, and delicious flavor, quite similar to the good "old Antwerp." A very promising variety.

Franconia.—Half hardy, vigorous, and very prolific; fruit very large, bright-red, firm, of a sprightly flavor; one of the best, most vigorous, and prolific of the foreign varieties.

Highland Hardy.—Canes very hardy, strong grower, and wonderfully productive on any soil; fruit medium, bright-red, and fair quality, which ripens very early; owing to its extreme hardiness, productiveness, and good market qualities, we consider it "the raspberry for the million."

VARIETIES FOR HOME USE.

Brinkle's Orange.—Canes tender, vigorous, and productive; fruit large, beautiful golden-yellow, and the most delicious raspberry grown, the acme of perfection for home use.

Clarke.—Canes hardy, strong grower, and productive; fruit large, light scarlet; very fine flavor; a good table variety, but too soft for market.

Hornet.—Canes half hardy, vigorous, and prolific; fruit very large, bright crimson, and excellent flavor; a very superior variety for the garden.

BLACK-CAP VARIETIES.

Doolittle.—Hardy and very productive; fruit medium black, good flavor; a standard market variety.

Davison's Thornless.—Hardy, vigorous, and productive; the canes are as "smooth as a willow," which alone makes it very desirable as a garden variety, while the fruit is large, black, sweet, and fine flavor; very early; one of the best black-caps for the garden.

Mammoth Cluster.—Canes hardy, very rank grower, and wonderfully prolific; fruit very large, black, with a rich bloom, very juicy and good flavor; the best late variety for the market.

Seneca.—Canes hardy, vigorous, and productive; fruit large, black, very sweet, and delicious; the best flavored variety; also, the very best berry for canning.

Golden Summit.—The canes are half hardy, being a rank grower; quite productive; fruit large, bright golden-yellow, a most beautiful and delicious fruit for the dessert.—*N. E. Farmer.*

THE WONDER OF THE WORLDS.*

By CAMILLE FLAMMARION.

IF you should chance some day to take a short trip to the planet Saturn, which is scarcely more than 800,000,000 miles from here, you would experience at its aspect an indescribable astonishment that would certainly bear no approach to any like feelings that you have ever experienced on earth. Just imagine an immense globe, not only of the size of ours, but of as great a volume as 864 earths heaped up together! It whirls around on its axis with such velocity that, notwithstanding its size, it accomplishes its daily revolution in about ten hours. On a plane with its equator, and at about 20,000 miles distance, an immense and comparatively thin ring completely encompasses it. This ring is, in its turn, surrounded by a second ring, and the latter by still a third. Now this system of multiple rings is scarcely 300 miles in thickness, while it measures 37,000 miles in breadth. The rings are not stationary, but move in a circle about the planet, and with a velocity greater than that of the planet itself. But the domain of the Saturnian world does not end here; for, beyond the ring, are observed *eight moons* circulating in the heavens around this strange system. The nearest of these satellites is separated from the exterior ring by a distance of 37,000 miles; the farthest follows an orbit which is about 2,700,000 miles from the center of the planet. Saturn, then, commands a world which measures no less than 6,000,000 miles in diameter, that is to say, 18,000,000 miles in circumference!

This is a world by the side of which the earth cuts a very modest figure; and Micromegas was very excusable in taking our globe for a celestial mole-hill, when, leaving Saturn, he passed in the neighborhood of our abode. Its years are thirty times longer than ours: its seasons each lasts seven years and four months, and they are marked by diversities that are sensibly like those that distinguish our own. A regenerating spring succeeds a rigorous winter, and a summer and autumn there exhibit their flowers and fruits.

But the phenomenon which attracts most attention to this world is the gigantic ring that completely encompasses it. For a long time it was impossible to ascertain the nature of this appendage, which is unique in the whole planetary system.

Galileo, who was the first to see on each side of Saturn something brilliant, but the form of which he could not distinguish, was greatly amazed at such a sight. He announced it at first, under an anagram, in which Kepler himself could recognize nothing; and, as he had done in the case of Venus, in hiding his discovery he gave himself the time to bring it to a successful issue.

In awaiting a better name, he called Saturn *tri-corps.* "When I observe Saturn," wrote he later to the ambassador of the Grand Duke of Tuscany, "the central star appears to be the largest; two others, one situated at the east and the other at the west, on a line which does not coincide with the zodiac, seem to touch it. These are like *two servants who are aiding old Saturn to perform his journey, and who ever remain at his side.* With a telescope of the lowest power, the star appears oblong and olive-shaped."

But the industrious astronomer looked in vain. He was not favored in his researches as he had been in former ones. At the time when Saturn's rings are turned towards us edgewise, they are invisible on account of their thinness.

On a certain evening, Galileo, finding it absolutely impossible to distinguish anything on each side of the planet where some months before he had observed the two luminous objects, was in complete despair, and made up his mind that the lenses of his telescopes had deceived him. Greatly discouraged, he no longer bestowed his attention on Saturn, and died without knowing that the rings existed. Later on, Hevelius in a like manner declared that all labor was being lost there, and it was only in 1659 that Huygens, the true discoverer of the ring, gave the first description as well as the first explanation of it.

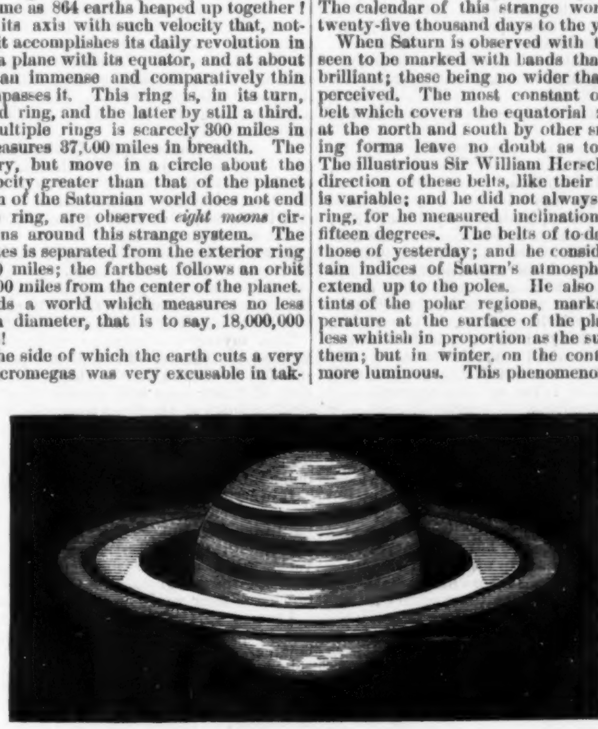
To the contemporaries of Galileo, Saturn was a *bowl with two handles (ansæ)*, and, again, a *cardinal's hat.* Later still, it was likened to a *soap-ball in the middle of a barber's dish.* In the middle of the eighteenth century, Maupertuis conjectured that the ring was merely a comet's tail rolled like a turban around the Saturnian globe!

Toward the end of the same century, Du Séjour wrote his "Essay on the Phenomena relative to the Periodical Disappearances of Saturn's Ring," in which he gave theoretically the time of the ring's rotation. He offered his work to Voltaire with the following graceful dedication: "Sir, be pleased to receive the history of a respectable old man upon whom attention will be bestowed on earth so long as wisdom shall be honored among men; his forehead is adorned with an immortal crown, and he enlightens us and exhibits to us one of the most singular phenomena of nature. This old man is Saturn, and I make haste to name him, for fear that another one might be designated whose portrait your modesty would prevent you from recognizing. May this analogy merit on your part a favorable reception for my work." Without the last remark, Voltaire himself, and better than any one, might have supposed, in fact, that Saturn was entirely foreign to the dedication.

After Jupiter, Saturn is the largest of all the planets, its mean diameter being 73,000 miles, or, in other words, its diameter is to that of the earth as 9 to 1. Its time of revolution around the sun, which fixes the length of its year, is twenty-nine years one hundred and sixty-six days and twenty-three hours.

This planet passes over one degree in thirty days, and a sign of the zodiac in two years and a half. As for the time of rotation of so enormous a planet around its axis, it is accomplished with prodigious rapidity, for the length of one of Saturn's days is no more than ten and a half hours. The swiftness of this movement has produced a considerable flattening at its poles, and which Bessel has estimated at a tenth of the total length of the planet's equatorial diameter. The calendar of this strange world embraces no less than twenty-five thousand days to the year!

When Saturn is observed with the telescope, the globe is seen to be marked with bands that are alternately dark and brilliant; these being no wider than Jupiter's, but less easily perceived. The most constant of all is the large grayish belt which covers the equatorial zone. This is surrounded at the north and south by other smaller ones, whose changing forms leave no doubt as to their atmospheric origin. The illustrious Sir William Herschel had remarked that the direction of these belts, like their form and even their color, is variable; and he did not always find them parallel to the ring, for he measured inclinations that were as much as fifteen degrees. The belts of to-day would often differ from those of yesterday; and he considered these changes as certain indices of Saturn's atmosphere. These belts do not extend up to the poles. He also perceived in the changing tints of the polar regions, marks of the variation of temperature at the surface of the planet. These regions were less whitish in proportion as the sun had the longer shone on them; but in winter, on the contrary, the pole was always more luminous. This phenomenon reminds one of the different alternations of brightness that the poles of Mars successively exhibit. "Whether or not," says Humboldt, "this increase of intensity should be attributed to the temporary formation of ice and snows or the accumulation of clouds, it always exhibits effects that are produced on an atmosphere by variations of temperature."



THE WONDER OF THE WORLDS.

One of the most remarkable peculiarities of Saturn's globe is its density, which is equal to three-fourths of that of water, and which decreases towards the surface. By reason of this circumstance, it is absolutely impossible for us to gain an idea of its material constitution and its molecular state; and we are not even allowed to decide whether or not the body of the planet is in a solid condition. For a long time past, some have believed that they resolved the problem by stating that the planet might indeed be composed of light materials, like pumice stone or wood. It has been remarked that the matter of which Saturn is composed is so light that if the globe were placed in the middle of an immense ocean it would float upon the surface of the water like an enormous fir-wood ball. If water forms an integral part of the planet's composition, it must exist therein only in the form of snow and ice at the poles, and in a fluid state on the rest of its surface; from whence it may be concluded that the beings which inhabit it are of an entirely different structure from those of the earth, and possess an organization adapted to the particular vital conditions which have been made for them.

In the seventeenth century, an ecclesiastic of Avignon, named Gallet, endeavored to attract the attention of astronomers to the position of Saturn, and which he said was eccentric to its ring; but his voice was unheard, and it was not till two centuries afterward, in the year 1817, that the fact was verified by Schwabe. In fact, the globe of Saturn is not regularly concentric with the ring, but inclines a little toward the west. It is thought that these differences, which appear to be periodical, are caused by an oscillation of the ring's center of gravity around the central point of the planet.

We on earth have the fault of considering those regions where individuals of our species could not live as radically uninhabitable. It is to hold a very sad opinion of the power of Nature, to believe that she constructed enormous globes at immeasurable distances and did not finish her work by placing inhabitants on them. If we should judge of the temperature of Saturn and even of that of Jupiter by the remoteness of these two planets, according to our way of seeing things, we should not hesitate for an instant to declare them uninhabited by reason of the cold that must prevail upon them. We cannot imagine that men may exist who do not possess the same structure and the same needs as we.

* Translated from the *Journal des Connaissances Utiles* for the SCIENTIFIC AMERICAN.

The distance from Saturn to the sun being more than nine times greater than that of the earth, the heat of the sun is ninety times less than it is here. Perhaps it is more condensed by an atmosphere there; perhaps that immense globe emits some heat itself; and perhaps the Saturnians would die of suffocation on the frozen seas of our North Pole.

The conditions of life in Jupiter, Saturn, and even in Uranus do not appear to differ any more from those of the earth than the condition of the terrestrial animal differs from that of the fish. "The inhabitants of Saturn," said Huygens, in his time, "have no more cause than owls and bats to complain of the little light that they receive from the sun, for it is more advantageous and more agreeable to enjoy the glimmer of twilight, or the light which remains during night, than that which lights up the earth during the day." The great Dutch astronomer added: "The inhabitants of Saturn not only enjoy the same sights and the same pleasures that those of Jupiter do, but they also have more beautiful ones, because of their five moons as well as because of the beautiful aspect of the ring that they see day and night. On Saturn, only the planet Jupiter is seen, and this, for its inhabitants, is what Venus is for us."

Fontenelle, who was always so ingenious in determining the conditions of existence in the planetary worlds, expresses himself thus in regard to Saturn: "We would be much astonished to see over our heads at night that great ring, which would extend as a half-circle from one end of the horizon to the other, and which, reflecting the light to us, would produce the effect of a continuous moon. . . . However this may be, the people of Saturn are pretty unfortunate, even with the help of the ring. It gives them light, but what a light at the distance it is from the sun! The very sun, which they see a hundred times smaller than we do, is for them only a small pale white star with but little brightness and heat; and should you place them in the coldest of our countries—in Greenland or Lapland—you would see them sweat great drops of perspiration and expire of heat! If water they had, it would not be water for them, but a polished stone, marble; and spirits of wine, which never freezes here, would there be as hard as our diamonds."

After having taxed the men of mercury with folly by excess of vivacity, because of their proximity to the sun, Fontenelle treats those of Saturn as phlegmatic for the contrary reason. The inhabitants of such a world must assuredly differ strangely from us, from every point of view. The specific lightness of Saturnian substances and the density of the atmosphere will have led vital organization in an extra-terrestrial direction, and the manifestations of life will have been produced and developed there under unimaginable forms. To suppose that nothing is fixed there, that the planet is liquid, that the living beings, in a word, are gelatinous, and that everything there is unstable, would be without doubt going beyond the limits of purely scientific induction. But it is beyond all dispute that this, of all the worlds of the system, is the one that approximates nearest such a state. The conditions of gravity are not only strange there, but they even vary from one latitude to another.

On account of the velocity of rotation, gravity is lessened one-sixth at the equator, so that while, in the polar regions, objects weigh more than they would upon the earth, at the equator they weigh less. On our globe a falling body passes through a space of 16 feet the first second of its fall, and on Saturn 17·5 feet in polar latitudes, but only 14·8 feet in the equatorial regions. If Saturn only revolved two and a half times more rapidly, objects would no longer have *any weight at all* in those regions! Moreover, the contrary attraction of the ring further diminishes the weight in a notable proportion, and there is a zone between the interior ring and the planet where bodies are attracted equally from above and below. It does not require a very great effort of the imagination to assume that, if an intermediate atmosphere permits it, the aerial inhabitants may enjoy the faculty of flying as far as the rings.

Do they dwell in atmospheric regions? Is Saturn an aerial world whose natives live seated upon cloud thrones, as was Olympus in mythologic times, and where formerly reigned Saturn himself, Jupiter, Mars, Venus, and the whole court divine?

Had Sir Humphry Davy penetrated the secrets of heaven when he gave the following curious description of the inhabitants of the planet under consideration?

"These gigantic beings of an indescribable form," says he, "appeared to me to be provided with a system of locomotion analogous to that of the sea horse, but their movements were effected by the aid of six membranes, which they made use of as if they had been wings. Their colors were beautiful and varied, especially azure and rose. The forward portion of their body was provided with a great number of coiled and movable tubes, whose form reminded me a little of elephants' trunks. . . . I experienced an unusual fear when I saw one of them take flight and rise toward the clouds. . . . These beings live in the atmosphere. Their degree of sensibility and happiness greatly surpasses that of terrestrial beings; they are endowed with numerous senses; they have subjugated the forces of nature, and, owing to the density of their atmosphere and the specific gravity of their planet, they have been enabled to determine all the movements of the solar system with precision. The first comer among them might be able to tell where the terrestrial moon was by calculation, without having seen it. Their minds are in a constant state of activity, and this activity is a perpetual source of enjoyment. They feed on fluids and live upon their clouds, which they manage like aerial chariots," etc., etc.

It is an indisputable fact that the world of Saturn is more aerial than ours, and that its atmosphere plays an important part, while the density of bodies there is very slight. This atmospheric pressure would be indeed tremendous were the Saturnian world as cold as its distance would seem to indicate, but it may be greatly diminished by heat. Now, telescopic observations lead us to believe that in fact the quantity of heat there is greater than that which would result from the distance from the sun.

But what is the nature of those marvels, the rings? Are they solid, liquid, or gaseous? They are, we have said, broad and flat (like a circle of cardboard placed around a terrestrial globe), and touch their planet at no point. Strange equatorial girdle! Sometimes they show themselves to us edgewise (this happened in 1878), and their thinness causes them to disappear entirely and makes the Saturnian globe appear as if only traversed by a thread.

Whether they be three in number or more, they cannot be solid, and resemble, for instance, flat circles of greater or less width. The constant variations of the planet's central attraction, combined with that of the eight satellites, would not only have dislocated and broken them if they had been able to form such a solid structure, but would have, in advance, absolutely prevented such a formation. It would be easier to admit that they are liquid, for in this case their elasticity might be able, so to speak, to lend itself to all the vagaries of attraction; but in this case there would be a transformation of motion into heat, a diminution of motion and a positive fall upon the planet. Are they then gaseous? The transparency of the inner one might give credence to such a belief; but such, however, is not the fact. What, then, ought we positively to think of their nature?

This is a problem in regard to which I entered into a mathematical discussion in 1867, and which led me to the conclusion that the only system of rings that can exist is a system composed of an infinite number of *distinct particles revolving around the planet with different velocities, according to their respective distances.* These particles, I added, may be arranged as a series of narrow rings, or each one of them may move irregularly. No refraction being observed upon the limb of the planet seen through the interior ring, it follows that this ring is not gaseous and that the rays do not pass through a gas. The other two rings may be of the same nature, but formed of such a multitude of particles that it is impossible for them to be transparent.

According to my calculations, the particles which form the transparent ring must revolve about the planet in a period included between 5 hours and 50 minutes and 7 hours and 11 minutes, according to their distance from Saturn, the nearest zone revolving most rapidly; those which compose the large bright ring must revolve in periods comprised between 7 hours and 11 minutes and 11 hours and 9 minutes, also according to their distances; and finally, the exterior limit of this singular system must accomplish its revolution in 12 hours and 5 minutes. But the eight satellites which gravitate outside of the rings must be the cause of considerable perturbations in these motions, and it is perhaps to the unstable equilibrium that they keep up that is due the preservation of the Saturnian appendage; for it seems that, without their support externally, the unavoidable frictions and shocks that take place would at every instant necessarily put the stability of this strange crown in jeopardy.

Supposing the ring solid, Laplace had estimated 10 hours and a half as the time of revolution, and Sir William Herschel believed that he had observed a movement of the same duration. But this period can only pertain to a zone situated in the upper quarter of the broad central ring, and not to the rest of the system.

In fact, it has not been verified by modern observations. The ring could revolve as one entire piece only if, its mass being enormous, its parts should obey this mass rather than the attraction of the planet. Perhaps it increases in thickness up to near the middle of the *central ring.*

This mysterious annular system appears to be slowly nearing the planet. Perhaps it is progressively descending spirally thereupon like a whirlwind, and perhaps astronomers of future ages will witness the grand spectacle of the sinking down of the rings upon the Saturnian world.

Let us complete this study by transporting ourselves in imagination to some point of Saturn's globe. From there let us cast a glance at the appearances that the celestial dome must present during day and night.

If we start from either pole and proceed as far as the 63d degree of latitude, we shall travel over every spot of the Saturnian hemisphere where the triple ring is *never visible.* The satellites alone rise above the horizon and exhibit the varied aspect of their phases to the spectator. The Saturnians of these regions, provided they have not traveled, do not know their world as well as we do.

Leaving this latitude, the annular system begins to be visible. But it is only during the two seasons, spring and summer, that the face of the rings turned toward the hemisphere where we are situated receives the sun's rays and illumines the planet's nights by reflection. During the day their arches send only a feeble light, which is doubtless analogous, as regards color and luster, to that of the moon when visible in broad daylight.

The form and extent of the immense luminous arches vary, moreover, according to latitude. On leaving the 63d degree and advancing toward the equator, they are observed to rise more and more above the horizon. At first it is a small portion of the exterior ring, then this ring in its total width. In mean latitudes of 45° there are perceived the two first rings, and between them the space by which they are separated. In proportion as we descend toward the equatorial regions, the entire system becomes visible; but at the same time, the visual rays having a more oblique direction, the rings diminish in apparent breadth.

At the very equator they are no longer visible except by their interior edge. This edge then looks like an immense luminous ribbon extending from east to west, and passing through the zenith.

What a marvel is this ring seen from Saturn itself, and how pleasant it would be for some artistic person to take a short trip thither!

Such is this vast Saturnian world, which is wandering on at more than eight hundred millions of miles from here, a distance at which our abode becomes nothing more than a point visible in the telescope only, and like a microscopic black spot, which from time to time crosses the sun.

THE GEOLOGY OF GIBRALTAR.

The following facts are from a paper by Professor A. C. Ramsay and James Geikie, in the *Quarterly Journal* of the Geological Society for August, 1878. More than three-fourths of the promontory of Gibraltar consists of a grayish white bedded limestone, containing occasional casts of Rhynchonellæ and encrinal stems, the former closely like *R. concinna*, a species abundant in the Cornbrash and Coral Rag. The limestone is overlaid by shales of various shades of color, with some thin calcareous beds, which have afforded no fossils. The dip of the rocks is in general over 40°, and, in some parts, 75° and higher. Upon these beds there are superficial deposits. The oldest is a limestone breccia, covering a large area in the district of Buena Vista and Rosia, and in the vicinity of the South Barracks; it is unfossiliferous. The authors attribute the origin of the limestone fragments of which the breccia consists to the frosts or cold of the Glacial era. The mean temperature of the coldest month (February) is now 54·2°, and the lowest point reached in the six years, from 1853 to 1859, was 32·7°; and no debris is now forming from such a cause or any other. Besides these surface breccias or conglomerates there are also bone-breccias in caves and fissures. The famous bone-breccia at Rosia Bay occupies a vertical fissure of erosion in the above-described surface breccia, while the Genista breccia occurs in a true cave.

The promontory bears evidence of different sea levels in terraces or platforms cut in the solid rock, surmounted sometimes by calcareous sandstones. The Europa Flats is one of these sea levels on the southern portion of the promontory; it extends from west to east for 1,650 feet, and it averages 115 feet above the sea level, though sloping up from 90 feet to 150 feet. It appears also at other points. The calcareous conglomerate over it contains some remains of Mediterranean species, and is evidently of marine shore origin. Another such terrace has a height not less than 250 feet; a third, about 830 yards in length and over 330 broad, is 370 feet above the sea. In the front of the same cliffs, at a height of 170 feet, an oyster bed was formerly visible.

Among the species of mammals identified by Messrs. Busk and Falconer from the Genista cave, there are *Rhinoceros hemitæchus*, horse, boar, *Cervus elephas*, *C. dama*, ibex, bear, wolf, *Hyæna crocuta*, lion, panther, lynx, etc., and these authors concluded that, at the time these animals were living, Europe and Africa were at the same point united across the Mediterranean. With this in view, the succession of quaternary events in Gibraltar is given as follows:

(1.) Great unfossiliferous limestone agglomerate of Buena Vista, etc. Land of greater extent than now; winters very cold; Gibraltar apparently not tenanted by the quaternary mammalia.

(2.) Caves and fissures with bone-breccia. Land of greater extent than now; Europe and Africa united; climate genial; immigration of the African mammalia.

(3.) Platforms or terraces of marine erosion (in part), calcareous sands, etc. Depression of the land to the extent of 700 feet below present level; movement interrupted by pauses of longer or shorter duration; climate apparently much the same as now.

(4.) Platforms of marine erosion (in part); Alameda sands; formation of sand slopes on east coast, as at Monkey's Cave; mammalian remains under beach or later limestone agglomerate (perhaps cave deposits in part). Re-elevation; land of greater extent than now (Africa and Europe perhaps reunited); climate probably genial.

(5.) Later limestone agglomerates resting upon and obscuring erosion terraces and sand slopes, etc. Geographical conditions probably same as during part of 4; winter considerably more severe than now.

(6.) The present. Characterized by the absence of the action of frost.

On the conclusion of the reading of the paper, the statement was made by Admiral Spratt, that to the westward of Farifa Point a submarine ridge exists which nowhere exceeds 130 fathoms in depth; so that an upheaval of about 800 feet would connect the two continents by dry land.

DOG LORE.

An instance of innate depravity was developed on the farm, in western New York, of the grandfather of the writer of this article. For miles around sheep were bitten, at intervals, night after night; but none of those on the ancestral farm were touched. Still, Elder Wyckoff's dog was suspected, and had been partly identified, though not overtaken, in one or two instances. The owner could scarcely believe ill of the dog, and no trace of the crime was ever visible on its clean hide.

At last, one night, the Elder left his bed to investigate the subject. Sure enough, the dog was absent. It was afterwards ascertained that the animal had gone to a farm twelve miles distant, and there had bitten a score of sheep. The Elder waited till near daybreak, and then saw the culprit coming rapidly homeward; but the dog did not see his owner, who was concealed. Now ensued the most curious part of the performance. The dog went into a small stream of water, near the house, and washed himself carefully, getting rid of the sheep's blood with which his mouth and hair had been stained. Then he laid himself down in the grass, rolled over, shook himself, and went to his kennel. Of course, he was shot before sundown.

A controversy has been going on for several weeks in the columns of *Nature*, as to whether animals ever perform abstract reasoning. It appears to us that the instance we have described is very much to the point. No theory of inherited instinct seems adequate to explain why the dog that killed sheep at a distance always spared those of his master; or why that dog washed off the traces of guilt after a midnight foray.

A more interesting question arises as to how far animals understand human speech. In a well-known family living near Doylestown, Penn., there was kept a dog that had become old and worthless. One day at table the owner quietly remarked that he was going to shoot the dog, as there was no use in keeping him. The animal evidently heard the remark, and immediately rose up and walked out of the house. That dog has never been seen since; whether he committed suicide is unknown. He was supposed to be too feeble to wander very far, but he certainly did not come back. Names and date can be furnished, if needed, as to the foregoing facts.

The writer has witnessed a few instances of this kind of intelligence. In one case a lady mentioned to him that her pet dog had a great aversion to water, and that she had varied the week-day for washing the dog several times, because, if a uniform system was adopted, the animal would hide himself on the regular day. The dog—a small hound—lay apparently asleep on the sofa. Presently, without raising or varying the tone of conversation, the lady said, "I mean to wash the dog this afternoon." A moment afterward, the animal slipped quietly out of the room. Then the house was searched from garret to cellar without finding him; the dog did not put in an appearance the rest of that day.

A Philadelphia lady, now dead, whose accuracy of statement in any other instance we should never have doubted, told us the following story, which seems too marvelous for belief. Her mother was in the habit—as were many ladies of that city in old times—of making her own purchases of marketing. One morning an old gentleman of her acquaintance, similarly engaged in buying, found that he had one chicken too many for his basket, and insisted upon transferring the fowl to hers. When she brought home her marketing and deposited it in the kitchen, taking up the fowl, she handed it to the cook with the remark: "I wish I had another chicken; it takes at least two to make a dinner." Thereupon, the family dog, which had been stretched upon the window-sill, jumped out of the window as if something had attracted him. The dog staid away about half an hour, and came back with a chicken in his mouth; laid the burden down, and retreated to his usual seat on the window-sill. The chicken was yet warm, though dead; the dog had seized it by the throat. It was not known whose poultry yard had suffered. The lady who told the story ate a piece of the chicken.—*Science News.*